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Mechanical and Engineering Section.

Stated meeting held Thursday, October 16, 1901.

MR. JAMES CHRISTIE in the chair.

THE CONSTRUCTION AND INSPECTION OF STEAM BOILERS; WITH ESPECIAL REFERENCE TO THE "CITY OF TRENTON" DISASTER.

DISCUSSION.

MR. JAMES CHRISTIE:—Gentlemen, in the absence of the president of the Section, I have been requested to take the chair at the meeting; and as there is no other business of importance, we will proceed at once without any formality to the subject chosen for general discussion this evening.

The subject, as announced on the bulletin, is "The Construction and Inspection of Steam Boilers; with especial reference to the 'City of Trenton' disaster." The Committee on Sectional Arrangements has requested Mr. Samuel M. Vauclain, Superintendent of the Baldwin Locomotive Works, to open the discussion.

[Before proceeding with the discussion, Mr. Vauclain read a letter which he had addressed to the Neafie & Levy Ship

PLATE I.—Front end of exploded boiler of the "City of Trenton," showing crown-sheet with part of tube-sheet attached.

PLATE II.—Exploded boiler lying on one side with tube-sheet to left and side of fire-box seen above.

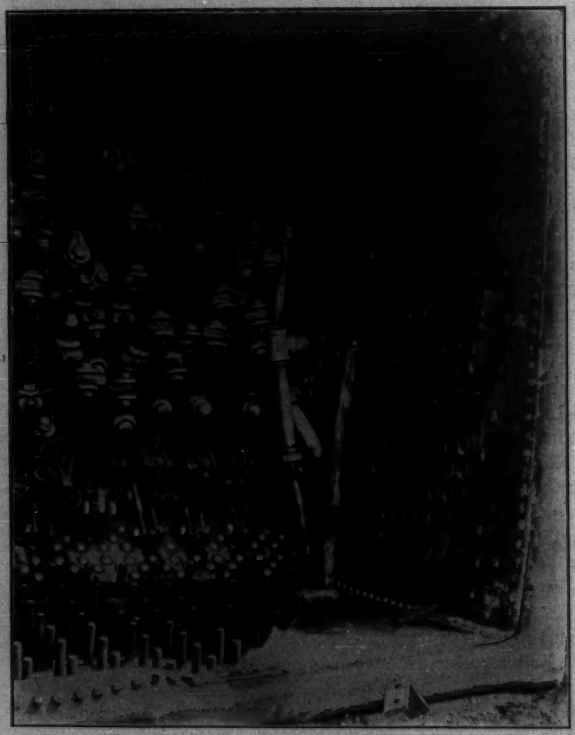


PLATE III.—Enlarged section of Plate II showing ruptured tube-sheet and end of tubes.

Engine Building Company, the builders of the boilers of the "City of Trenton," asking for data referring to certain details of construction for a section of plate taken from the exploded boiler, for the purpose of making tests of same, and for information concerning the location of the exploded boiler on the boat, and the steam and water connections thereto.

To these inquiries an answer was received, the Counsel for the Company, J. Warren Coulston, Esq., saying in substance that, in his opinion, the present was an inopportune time to investigate the subject.

The chairman, therefore, stated that, in his judgment, the proposed discussion at this meeting would simply amount to an exchange of individual opinion among the members of the Section on the subject in its general bearings for the purpose of eliciting information respecting the construction and inspection of steam boilers, which would not represent the opinion of the Franklin Institute, and asked the meeting whether there was any objection to proceeding. No objection being offered, the chairman requested Mr. Vauclain to open the discussion.—THE SECRETARY.]

MR. VAUCLAIN:—Shortly after the explosion of the boat, through the courtesy of Mr. J. Shields Wilson and Mr. Sommers N. Smith (Mr. Wilson, I believe, operated the boat and Mr. Smith built the boat and also the boiler), I was permitted to view the exploded boiler on the wharf. This was a few days after the boiler had been taken out of the river.

It required but a glance at the condition of the crown-sheet to explain why the crown-sheet had blown down and the boiler had caused the damage that happened on that eventful day. The holes in the crown-sheet through which the crown-stays had been screwed were elongated, and were also enlarged in their upper diameter; or, in other words, in the diameter not next the fire but next the water —which indicated that as the sheet being hot, these holes had gradually enlarged in the upper diameter until the rivet-head of the stay could no longer hold it in position.

I have with me three photographs which were taken of

the boiler as it rested on the wharf. A glance at the point there of these two would, I think, enable any one who has ever had any experience with locomotive boilers at once to understand—I find the Secretary has slides of these three and will show them on the screen.

The crown-sheet is in this section and was the part that first became overheated; and the condition of the holes are as you will notice: there is one which shows very plainly (the direction in which the light comes through the holes rather spoils the picture); but in this one you will notice how the sheet is drawn, drawing the holes in an oblong shape. There were a number of these holes that were so drawn, and all in this vicinity.

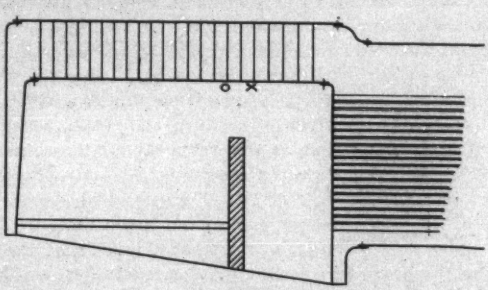


FIG. 1.

The picture now shown is a view showing the interior looking into the roof of the boiler, showing where the flue-sheet tore away and passed out with the crown-sheet. The crown-sheet is here, and shows very plainly the distortion, the holes being oblong and the sheet showing a corrugated appearance—part of it between these crown-stay holes.

This one gives you, perhaps, a little better idea of it. The light strikes it in a somewhat different manner. The light shadow on this print does not indicate the hole. Of course, a portion of the hole is shown in the very dark shadow. You will notice that the direction in which the photograph is taken shows the edge of the plate in the hole, as well as what light will pass through the hole; but

it brings out very clearly the distortion of the hole found in the sheet.

The starboard boiler, however, was in position in the boat, and afforded an opportunity for an expert to learn exactly how the boiler was operated whilst it was in service; and this is what was found (*Fig. 1*): The boiler, having the ordinary fire-box of a locomotive boiler, and the crown-sheet stayed and held in a similar manner to locomotive boilers, with the flues extending from the flue-sheet in the fire-box to the flue-sheet in the smoke-box. The length of the fire-box was about 9 feet 6 inches, but was shortened so as to give a grate-bar about 6 feet in length, as near as I could judge. Not having any drawings or accurate dimensions it is impossible for me to say what that length was; but at the end of these grate-bars a bridge-wall was built about 17 inches off the crown-sheet; consequently, all the products of combustion (the wall being there) had to pass over this bridge-wall on the road to the flues, and consequently the flames were concentrated on this portion of the crown-sheet. It is therefore evident that when the water in the boiler got to too low a limit or down to the crown-sheet level, that the violence of the heat at this point overheated the crown-sheet; even if there had been a very little water over it, it would have driven that water away; and as the stays were constructed in this manner (being merely an eye-screw screwed through the crown-sheet and riveted there, *Fig. 2*), this portion of the metal would be the first to become heated, because on the upper side the water could not reach the plate. But I attach very little importance to this, as the time that would be required to heat this red-hot would be a little longer than what would be required to heat the plate surfaces, so very thin, after they were once exposed. The action when the plate commenced to get hot was with the stud being screwed in that way, and another one over here; there is a pocket in that manner (*Fig. 3*); and of course, when the plate would pocket in this manner on the other side of

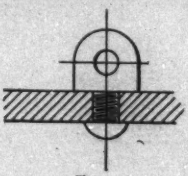


FIG. 2.

this stud the upper diameter would increase, and, consequently, the thread would slip—the thread of the stud—and the entire strain or load would be pushed or cast upon the rivet head of this stay. This in turn, being red-hot, would afford very little, if any, resistance; and if some of the old studs in the boiler are examined it will be found that just such a thing took place. The threads for at least one-half, and on some of them for two-thirds, are very good—are sloughed off somewhat, owing to their being hot; but the rivet end is pulled off, and some of them were sloughed off, as in the case of the one that you see before you: you can see the burr still adhering to the bolt. Those which were in a more remote part of the fire-box will show that a little more of the stud had been torn off with the sheet as it went down.

It is reasonable to suppose that when once three or four or a half-dozen of these stays became disengaged from the

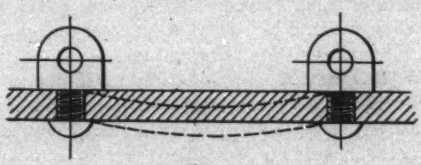


FIG. 3.

crown-sheet, nothing remained to happen but an entire rupture of the boiler; and as you noticed, from the pictures shown on the screen, that is just what happened: the sheet turned practically inside out—turned right down and extended slightly back, into the back head of the boiler, closing up the fire-box door-holes.

It is difficult to say very much about anything that requires little to be said of it; and this is one of those cases. It is difficult to theorize to any very great extent when we have evidence so plain before us as to what occurred, or as to what existed at the time this boiler exploded; the evidences in the sheet and in the end of the studs. Just how it was caused is perhaps a different matter, but certainly the primary cause of the explosion of this boiler was due to a

scarcity of water in it at the time that the crown-sheet let go. Mr. Chairman, I suppose that a great many present would like to have something to say in regard to this matter and I, for the present, will close my remarks. I do not wish, however, to have it understood that I have said all that I can say in regard to this matter, and would be pleased to answer any questions which any one may wish to ask me. [Applause].

THE CHAIRMAN:—There are quite a number of gentlemen present who I have no doubt will be very glad to say something on this subject; and we hope that they will not necessarily confine their remarks to this particular case, but to the subject of weaknesses of steam boilers, and boiler inspection, and boiler disasters in general. I would be glad to hear from Mr. John M. Hartman.

MR. JOHN M. HARTMAN:—Mr. LeVan was on the ground right after the boiler was taken out. He made a thorough examination of it, and would be in a better position to talk about it than I would be; and I would ask that you call on Mr. LeVan to present his observations.

MR. W. BARNET LE VAN:—On the ninth day of September I went inside of the exploded boiler. The lantern slides are misleading, from the fact that the background seems to show that the sheets bulged. The sheet was not bulged; neither was it bagged between the stay-bolts. Any one looking at the picture would think the sheet sagged down like the belly of a cow; but no such thing occurred. I examined the boiler and could find no sagging between the stay-bolts; I could find no evidence of heat whatever; I could see the line of the water-mark, some four inches above the crown-sheet, distinctly marked. The fact is, in the first place, that the mistake was made of having too coarse a thread on the stay-bolts; in the second place, they had too short a hold and an insufficient overhanging or rivet to hold it in place. The elongation of those holes no doubt occurred by the force of the explosion; the fact that the threads are torn off as though turned off in a lathe shows that they had not sufficient hold, due to the coarseness of the thread, which allowed them to strip off, as one would

tear apart a sheet of postage stamps. The faces of the sheet as it was driven against the front head indicated there were no cracks or bags whatever in the crown-sheet.

MR. VAUCLAIN:—Mr. President, as this is a flat contradiction of my statement, I desire the opportunity of answering Mr. Le Van. In the first place, gentlemen, my eyesight is good, and I can tell when a sheet is bagged as well as any one. It is not necessary when a crown-sheet is hot and is driven out of the fire-box and lapped around the back head of the boiler for it to bag down like the belly of a cow; but this sheet had decided bagging like that between the stay-bolt holes, or between the crown-stay holes; and the crown-stay holes were in that shape [indicating.] It would be very difficult to tap a hole exactly in that shape and screw

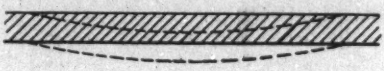


FIG. 4.

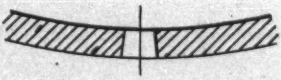


FIG. 5.

a straight stud in it. This diameter, the larger diameter, was on the upper side. Now, Mr. Le Van says that the reason why this crown-sheet came down was because there were not enough threads screwed through the crown-sheet to hold it there, and the riveting underneath was insufficient. I have personally superintended the construction of about 16,000 locomotive boilers, and in the majority of those locomotive boilers the crown-sheet was held with a stay which is screwed through and simply riveted over, and screwed through the roof-sheet as well. Any gentleman here present—if he will take the trouble to come to the Baldwin Locomotive Works—can see that construction every day in the year, and we have no trouble with them, and they hold. Furthermore, I have built hundreds of loco-

motive boilers to specifications in which this was the crown-sheet [indicating] and these were the crown-bars; this was a washer between the crown-bar and the crown-sheet some 2½ inches in diameter. The bolt was the T-headed bolt ⅞ inch diameter; whereas this stud was 1⅜ inch; the hole in the sheet was a plain hole, without a single thread in it, and the bolt was simply passed through and headed on the under side. Now, if no threads in the sheet would hold the crown-sheet with the rivet head turned underneath, it is fair to presume that two threads, or three threads, or four threads—but as I counted, in this sheet, I think, six threads, five of which were fully engaged, I think they were sufficient to sustain the load that was placed upon them.

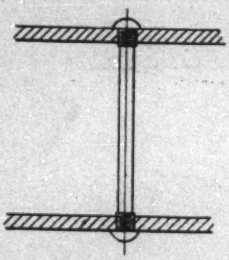


FIG. 6.

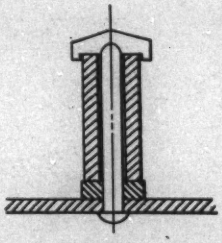


FIG. 7.

These stays carried each the equivalent of about thirty-nine square inches of surface, which at 175 pounds per square inch would make very little over 6,000 pounds (between six and seven thousand pounds) total load. The amount required to pull this stud out of this sheet with a very indifferently riveted head is a little over 40,000 pounds, which would be a factor of safety of 6. The sheets were ½-inch thick; and under the Government rules the space between the studs is within the limit. Or, in other words, that the sheet exposed to the pressure in its normal state would not bulge or pocket, but before it would bulge or pocket would have to be warm, and that was the condition in which I found this sheet.

MR. LE VAN:—How far apart do you make your stay-bolts? Do you make them $8\frac{3}{4}$ inches one way and $10\frac{3}{4}$ inches the other?

MR. VAUCLAIN:—We do not make our stay-bolts $8\frac{3}{4}$ inches one way and $10\frac{3}{4}$ inches the other way; and to the best of my knowledge nobody does.

MR. LE VAN:—Didn't this boiler have such?

MR. VAUCLAIN:—No! The entire area suspended between each bolt was 39 inches. (*Fig. 8.*)

THE CHAIRMAN:—The subject is now open for discussion; and I wish to remind the gentlemen present that in order to get at the facts of the matter, and in order that the audience may all understand, I think it may be well that the

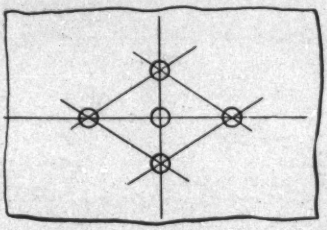


FIG. 8.

gentlemen present here will relieve the Chair and avoid, if possible, anything in the way of personal colloquy.

MR. JOHN M. HARTMAN:—Mr. Chairman, gentlemen, I wish to begin by saying that Mr. Wilson, President of the Steamboat Company—an old friend of mine—came to me with the request that I should investigate the cause of this explosion and get at the bottom facts. We will take first these lugs (*Fig. 9*), 10 threads to the inch. These shanks run about $1\frac{3}{16}$-inch long from the shoulder to the head of the rivet. The crown sheet is $\frac{1}{2}$-inch thick. Here at the shoulder is a groove $\frac{1}{8}$-inch wide, cut down into the screw, leaving only $\frac{3}{8}$-inch of good thread. This $\frac{3}{8}$-inch is further reduced by riveting over at the edge of the thread, which harms it. Practically we have three good threads. Then we have the

rivet, riveted over the edge of the hole about $\frac{3}{16}$-inch and drawn out quite thin. With that small amount of thread and the thin rivet head, we have not sufficient strength for holding up the crown. Here is a lug (*Fig. 10*), screwed carefully into the plate and is cut in two, to give a better idea of the section. To show the strength of these stay-bolts and the crown, a cast-iron frame was made to which to bolt a $\frac{1}{2}$-inch plate of the same quality as the crown-sheet. Four $1\frac{1}{4}$-inch bolts passed through the frame at the same distance as the stay-bolts are from center to center, to hold the plate to the frame. The central hole was tapped and a lug (*Fig. 10*), screwed in and riveted over, making all the conditions as nearly like the original as possible. On the testing machine, at 28,000 pounds, the rivet head cracked and

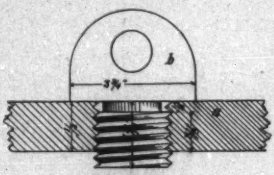


FIG. 9.

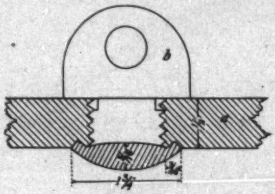


FIG. 10.

spalled around the edges, the lug kept yielding and the plate buckling for twenty-five minutes at 28,000 pounds, when 32,150 pounds was applied, which ruptured the lug and plate. The total buckling was $1\frac{1}{4}$-inch. The thread in the plate stretched and little damage was done to thread in the plate and the thread on the lug. The angle or incline of the thread stretched the soft plate sideways and allowed the lug screw to pull through it. In soft plate the pulling side of the thread should be at right angles to the center of the screw on the stay or lug. The strain on each stay-bolt at 175 pounds per inch (the Government allowance) of steam pressure is 7,122 pounds. At the Government test-pressure it was 10,684 pounds. The Government uses a factor of safety of 6 or the safe load must be $\frac{1}{6}$ of the breaking strain. This would call for a breaking strain of 64,104

pounds, which would give a factor of safety of 3 or about one-half what the Government allows. The working drawing of this boiler shows the details of the lug with the shank 2 inches long and threaded the whole length. For what reason was that 2-inch shank put on? The working drawing shows the stay-bolt lugs (or eye-bolts as shown) screwed into two thicknesses of ½-inch plate, whereas in reality it only screws into one thickness. Had a washer been put under the lug to keep the full depth of the thread in the plate and a deep rivet head turned over whose diameter would have been $\frac{21}{16}$-inch as used by Mr. Hartley, this crown-sheet would not have come down.

In regard to the crown-sheet the following is my opinion based on what I saw.

The crown-sheet gave way at the stay-bolt marked *x*, in exhibit (*Fig. 1*), near the middle of the sheet. The strain was then transmitted to the next two bolts, which gave way, followed by all the others. The crown-sheet buckled in coming down and tore off some of the stay-bolts bulging out at the sides and end of the boiler; the crown-sheet finally tore off about one-third of the tube-sheet and passed on down into the fire-box with part of the tube-sheet attached. The other end held on to the end-sheet, tearing part off and doubled over above the fire doors. The boiler went straight up in the air. The crown is intact, the tearing being below it. The flange near the top of the tube-sheet shows defective riveting. There was no explosion, simply a big puff when the boiler left the hull.

If the crown had parted over the bridge-wall, or at the hottest point, one part of it would have gone one way and part of it the other way. This, to my mind, removes all doubt about there being low water. The roll scale or surface, put on the plate of the crown in rolling it in the rolling mill, was still on the fire side of the sheet. I picked it off with my knife. This always disappears when a plate is overheated. The scale was in lamination and polished.

MR. VAUCLAIN:—Through the kindness of the Coroner, I think that I can explain why the stud was left 2 inches long. I have with me a blue-print of the boiler—supposed

to be the working drawing of this boiler; and as it was not given to me by the manufacturers, I felt that it would be a breach of etiquette for me to show it; but you will see before you the details of these studs. This stud is drawn in detail, as Mr. Hartman has shown: it is 2 inches long; it has a rather flat face there. That is, perhaps, what led the boilermaker astray slightly; although I think the error was a very unimportant one. The working drawing, in the other hand, shows that (*Fig. 11*) there is the crown-sheet; this is the back head; it shows an I-bolt that is rounded and then comes down like that, with a thread on, and comes on through and is headed over, and another headed over.

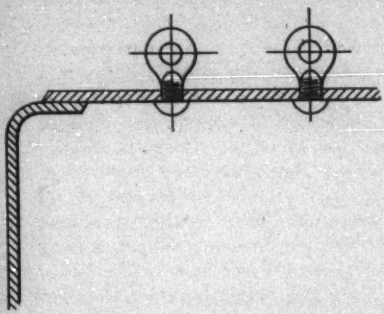


FIG. 11.

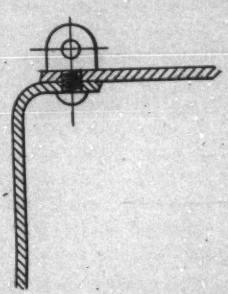


FIG. 12.

The intention evidently was on the part of the draughtsman, and the scale would indicate here that the distance from here down to what would be rivited over should be about 2 inches. His idea, no doubt, was to not have the thick metal come down on the crown-sheet any more than he could help it, but allow the water to get a little closer to this thread. The detail of the drawing being made in this shape, with a 2-inch prolongation, perhaps, led the boilermaker to believe that that was to be screwed down to the sheet, and then what he did not need on this end to be cut off and the rest was to be riveted over. In putting in crown-sheets in ordinary locomotive boilers, we always

leave the stud a little longer than necessary, so that the men may screw them through about the right amount to rivet over and then cut the other end off and rivet them over, also. I failed to find on this print, except in the rear view, which shows the stud carried down as Mr. Hartman indicated: there is the crown-sheet, which comes around in this way; and then there is an inner line showing the flange of the flue-sheet; or the back head, as you may please, and the stud has come on through both of those (*Fig. 12*) and that is clearly an error in the drawing-room, and frequently happens, to which the mechanic pays no attention, but takes the drawing to the drawing-room in a well-regulated establishment (if he is going to build a lot more of them) and has it corrected—and has it made that way. That deviation here is a matter for the boilermaker —the foreman of the boilermakers—to explain.

THE CHAIRMAN:—The subject is open for general discussion. Any gentlemen present, we would be glad to hear from them.

MR. GEO. B. HARTLEY:—I examined the boiler in the "Quaker City." It was similar in every respect to the boiler that exploded. I found the conditions that Mr. Hartman speaks of, and would say he rather under- than overstated them.

The head of every screw-stay within the fire-box had been caulked all around, leaving a well-defined groove, thereby weakening its hold.

It suggests itself to me, that after the stay was screwed to place, if enough material had been allowed to form an adequate head, after being riveted over by a light maul, that there would have been no leakage and no necessity for the objectionable after-caulking: The screw stays on the rounded part of the sheet did not get the full benefit of their threads—due to the sheet rounding away from them.

The stays inside of the boiler were formed by what may be called connecting links, some being fastened to that part screwed into the crown-sheet by pins while others were held in place by an ordinary bolt and nut. Many of these stays were loose and could be easily rattled; and while it is true

that when the pressure was applied to the boilers these stays would take a strain, it is a question that before doing so the stays already tight would be subjected to too great a tension, possibly to the point of giving way.

MR. ROBT. D. KINNEY stated, that so far as he had noticed in the matter of the boiler explosion on board the boat "City of Trenton," no attention seemed to have been given to the possible listing of the boat to starboard and its effect upon the water in the boilers, especially if the water was at the time very shallow over the crown-sheets, adding, that much list might practically have based the crown-sheet sufficiently to have caused it to have become overheated, which seemed to be the primary cause of the explosion.

FIG. 14.

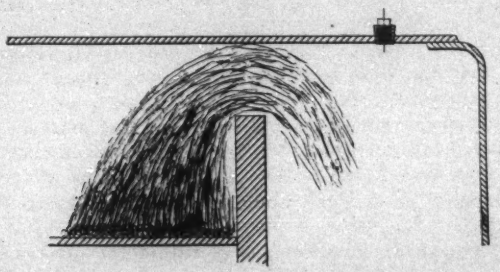


FIG. 13.

He remarked further that the crowding of the passengers to starboard through something attracting their attention generally to that side of the boat would be no unusual occurrence on an excursion boat loaded with passengers, as this boat was at that time of the disaster.

MR. VAUCLAIN:—I am the only one who can answer that. Here was the fire (*Fig. 13*); there was the bridge-wall, and I believe there was the fusible plug. The fire in being drawn from the flues was no doubt drawn in this direction, and secondly, deflected in that direction; so that this part of the sheet was much hotter than that part of the sheet (*Fig. 14*). I think any one who examined the exploded

boiler could find very little, if any, distortion in this seam through overheating, which gave sufficient evidence to me to think that the water was not as low as was testified to by the Government inspectors, or 10 inches below the crown-sheet. The water had probably barely reached the crown-sheet, or at the level of the crown-sheet, and this heat would drive the water away; but the proof is that the metal in the soft plug was about half run out, that is, that the metal had got soft enough in the soft plug to push down and have very little of it left in the plug; and you will notice that this plug is screwed in from the inside of the crown-sheet, whereas in my experience we have always screwed them up from the under part of the crown-sheet and tried to locate them in the hottest place, so that the plug—the head of the plug would receive some of the flame and a projection passed up into the crown-sheet here—as soon as the water got below that the heat would be transmitted through this metal sufficiently fast to allow this to blow out before the crown-sheet was actually bare. This plug was probably about ½-inch to ¾-inch above the crown-sheet. From the appearance of the thread it was barely through the lower side or just about flush with the sheet; consequently, in a well-protected position, up in that position, a large portion of the metal had passed out by the overheating, and you will remember reading the evidence as given at the Coroner's jury: it was like pulling teeth to get any admission from the Government Boiler Inspectors as to the exact location of this plug, or as to which would be the hottest portion of the sheet with the fire and bridge-wall in this position. One of the inspectors even went so far as to say, after finding he could not escape giving the desired information, that he thought perhaps the flue-sheet itself had blown out first and carried the crown-sheet down with it; but this is why the soft plug was only half melted out, instead of wholly melted out. With the soft plug down that way there, or there, the metal in the soft plug would have probably been entirely gone; although I do not think if the metal in the soft plug had gone out entirely that this

explosion would have been prevented. If these studs had had nuts on the under side like that [indicating *Fig. 15*] the time might have been prolonged a little; it might have taken two or three minutes longer before they would have had trouble; but the engineer testified to this (if I remember correctly—any one present has the privilege of correcting me) that he looked at his gages in the engine-room and felt that his water was all right; and that he went back in the engine-room and tried the water there and it was all right; but that he did not have as much water in that boiler as he had in the other boiler, and for that reason, and for that reason only, he immediately went to the feed-valve and opened the feed-valve wide on this boiler—wide open—and the feed-valve on the starboard boiler was only a half-turn open, which was $\frac{1}{8}$ full according to his evidence. It

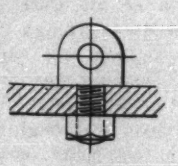


FIG. 15.

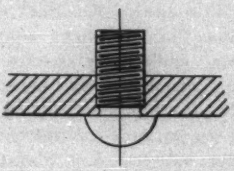


FIG. 16.

is an unusual thing for any engineer—locomotive or stationary—to open his feed-valve wide if there is only a variation in the boiler of about an inch between the water level as it was and as what he would like to have it. There certainly must have been in that man's mind a conviction that the water in that boiler was lower than it should be, and *much lower* than it should be, or he would not have immediately opened the feed-valve wide open.

MR. LEVAN.:—How does Mr. Vauclain's idea accord with the Franklin Institute test, that at 550° the metal is as strong as at 32°? Why should not the fusible plug have melted when it got to 701° when the pressure was 55,000 pounds to the square inch according to those measurements? That fusible plug was in a position to receive an intense heat: how could it be otherwise? The flame had

to pass right about it. If that sheet had been hot the plug would have melted, and not before. I can't conceive how Mr. Vauclain can assert that the sheet was hot when the fusible plug didn't melt.

MR. VAUCLAIN:—Mr. Chairman, I think that I just finished explaining, that from my point of view the fusible plug was not in the hottest place in the furnace, and that the sheet immediately over the bridge-wall was much hotter than the sheet was at this point, or at the point removed a slight distance from it.

The fact that the soft plug was not over the bridge-wall is conclusive that it was not in the hottest place; and any distance to which the soft plug was moved—placed from this bridge-wall—would remove it from the hottest place on that sheet. I have not the figures nor drawings to show exactly where that plug was; but the plug was approximately some 6 or 8 inches from the flue-sheet—so testified to, I believe, to the best of their judgment.

Now, a bridge-wall in a locomotive boiler is not an uncommon thing. There are many locomotive boilers built with bridge-walls. This boiler had forced blast.* What has a locomotive? The most violent forced blast that can be had. I have seen as high as 10—at one time 16—inches of water on a locomotive fire-box—locomotive fire. The heat is very intense; and quite frequently the crown-bolts, and especially where we use a headed crown-bolt with a button head screwed in, and those in turn are made like this [indicating *Fig. 16*], there is a groove underneath the head. Now the crown-sheet is $\frac{3}{8}$-inch thick and we cut two or three threads, and we get these two or three threads on the upper side, where in this case they are on the lower side of the crown-sheet; and the lower side—one-

* The following statement is added on the authority of Mr. Le Van.—[ED.]
The statement made, that forced draft was used on this boiler, upon investigation, proves not to be the fact.
Consequently, the heat being concentrated at the point *O X* in *Figs. 1* and *20* as stated is wrong, as there was no means by which forced draft could be produced. The heat was consequently equalized all over the under side of the crown-sheet.

third of the sheet—there is no hold in this sheet at all. Of course, we have the head as a safeguard, but nuts are used by some people. There are various ideas on this subject as to how to hold a crown-sheet up when it commences to get hot; and all locomotive crown-sheets don't go down when they do get hot, because they are caught in time; and when a sheet is treated in that manner by a careless engineer or fireman we call it a scorched crown—simply scorched: if it had been a minute or two longer it would have been a *hot* crown and it would have been down. It is no uncommon thing to have a crown-sheet hot enough for the sheet to stretch and let the bolt head pass up through it.

Referring back to the soft plug, I believe I said that the metal in the soft plug was half melted out; and as the Government required pure tin in this plug (which would melt somewhere near 450°) the inspectors testified that they did not put tin in this soft plug because it would not stand well enough—it would melt out too quick; and another alloy was used; and further, I believe, that lead was too soft. It takes a very great deal more to melt lead than it does tin; but the composition that was put in was supposed to melt, I believe, at 438°; where, by analysis of the metal that was in that soft plug we found that it didn't become limpid until it was between 500° and 600°, and did not melt, I believe, until about 650°.

[*To be concluded.*]

ELECTROLYTIC COPPER TUBES.

London *Nature* informs us that the Dumoulin process for the electro-deposition of copper in the form of tubes does not appear to have been very successful at Widnes, where a works for operation of this process was built in 1896–1897. According to the fifth annual report of the Electrical Copper Company it has been decided to close the works permanently and to sell the plant, since at no period of its operation has a profit been earned. The Dumoulin process depends upon the electro-deposition of copper upon revolving mandrils, specially treated strips of skin being used to supply the friction necessary for obtaining smooth and dense deposits. The process differs from the well-known Elmore process chiefly in this substitution of skin for agate burnishers; and it is noteworthy that in neither case has the financial success realized the early expectations of the promoters of the companies operating these processes.

THE FRANKLIN INSTITUTE.

Proceedings of the Annual Meeting, held Wednesday, January 15, 1902.

THE RENOLD SILENT CHAIN GEAR.

By J. O. Nixon.

The Renold Silent Chain Gear is one which may be run at high speeds, with no noise, for the transmission of any amount of power.

With this brief definition as a preface, we will proceed to a more detailed consideration.

Chain gearing, as a means of transmitting power between parallel shafts (with a positive velocity ratio), is one of those fundamental mechanical devices which each of us unconsciously reinvents at some time or another. It is theoretically obviously the correct method because of the following reasons:

(1) It provides a positive velocity ratio.

(2) It may be used on long or short centers.

(3) There is no loss from journal friction due to tension in the slack side of the chain, because such tension does not exist.

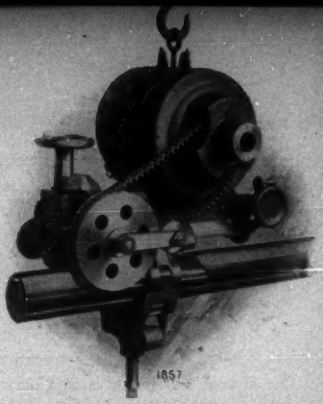
(4) It is not affected by heat or dampness.

While these advantages have long been recognized, it has still happened that in the majority of cases it has not been possible to employ chain gearing because of the large amount of noise connected with its use, and because of the low speeds at which it was absolutely necessary to run it.

It is by no means to be inferred, however, that only a small amount of drive chain is in use to-day. The amount made and sold every year aggregates many million feet, so that the actual number of chain drives is very large, but the proportion that they bear to the total number of power transmissions is small.

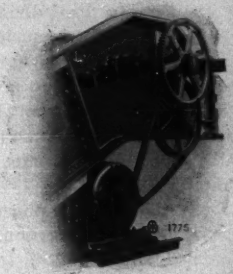
As stated above, the reasons for this limitation are the noise and the speed limits.

5-horsepower motor drive, 1,200 revolutions per minute. Drives counter-shaft.

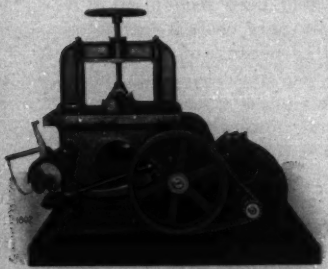


Motor-driven portable keyseater

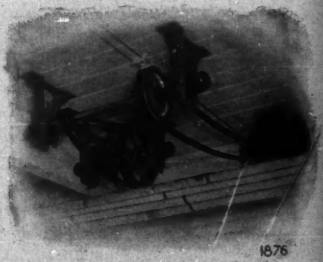
7½-horsepower motor drive. 875 revolutions per minute. Drives merry-go-round.



9 horsepower motor drive, 870 revolutions per minute. Drives stair lift.



3-horsepower motor drive, 1,100 revolutions per minute. Drives Higley cold saw.



1-horsepower motor drive, 690 revolutions per minute. Drives packing table.

RENOLD SILENT CHAIN GEAR, SHOWING VARIETY OF SERVICE.

We will now discuss the action of the ordinary chain gear and show the inherent causes of the above defects.

Fig. 1 will possibly make this clearer. The figure shows a driven sprocket wheel and a chain of the ordinary type. This chain, it is assumed, was made to fit the sprockets. However, as soon as the gear was started up, the pitch lengthened so that this is no longer the case. This length-

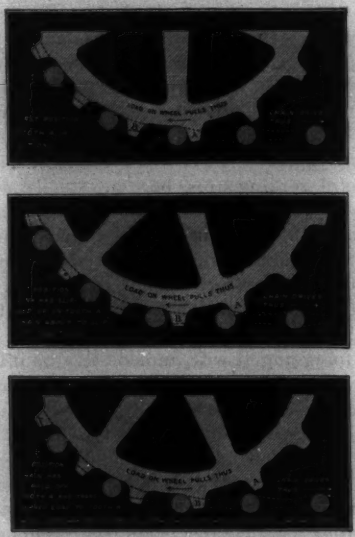


FIG. 1.—The action of an ordinary chain.

ening of the pitch, or stretch, is due to the following causes: The pins bed in their bearings, the stress on the chain stretches the material, which is, of course, elastic, and wear of the pins and of their bearings begins at once, and is a constantly increasing factor. Add to this the decrease in root diameter of the sprocket due to wear, and we have the conditions shown in the figure of a wheel running with a

chain that is too big for it. This means that one tooth alone is doing all the work at any given time.

In the first section of *Fig. 1* we have tooth *A* in action; in the second section the wheel has revolved and the chain is about to slip off tooth *A*, and in the third section the chain has slipped off, and the wheel has slipped back under the influence of the load, until tooth *B* comes in contact with the chain. This slipping back of the wheel makes a noise and causes a shock to both chain and wheel. These shocks occur every time a link passes out of mesh and, therefore, at even very moderate speeds, the number per minute is very large. It has been proved by experiment and by practice that this jarring action is very wasteful of power, and that the amount of power consumed by it increases more rapidly than the speed increases, so that the allowable useful working stress becomes smaller and smaller with increasing speed. This limits the speed at which a chain may be run. Of course, this limiting speed varies greatly for various styles of chain, and is much higher for a steel roller chain of proper design than for a malleable chain. What has been said above with reference to a driven sprocket applies with equal force to the driver.

From the foregoing it will immediately be inferred that the solution of the problem of producing a high speed and a silent chain gear lies in the production of a wheel and chain which shall always remain a perfect fit each with the other entirely independent of the stretch of the chain. Such a chain gear has been developed by Mr. Hans Renold, of Manchester, England, and has been in wide and successful use in Europe for some five years past. This chain gear consists of a chain composed of links of a peculiar form stamped from the sheet or cut from a drawn bar fastened together by shouldered rivets into a chain of any desired width, running over cut sprocket wheels with teeth of a shape varying with the size of the wheel. It is absolutely silent and may be run at high speeds. It is capable of transmitting any amount of power, from the smallest to the greatest.

How the Renold chain gear accomplishes its results may

be best seen by reference to *Fig 2*. It will be noted at once that the chain has contact with the wheel on the faces of the teeth only, and not on the root circle at any time. The flat bearing surfaces of chain and wheel at corresponding angles cause the chain to take the form of a perfect circle at all times, with a pitch diameter corresponding to the pitch of the chain, and not to the pitch of the wheel, as is the case where the bearing is on the root circle. Because

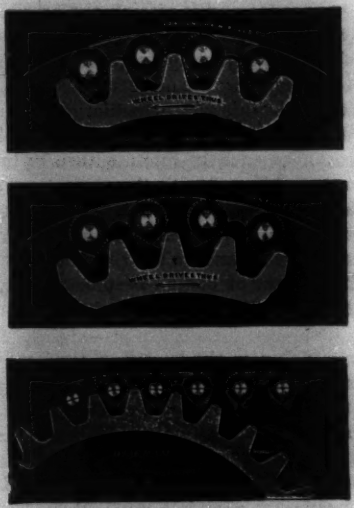


FIG. 2.—The action of the silent chain.

of the above, every tooth in mesh is in equal contact with the chain, and remains so, whatever the stretch. As any given tooth goes out of contact with the chain there is no slipping back of the chain, for the next, and every other tooth in mesh, is in perfect working contact with it. Thus there is no noise connected with the operation of the chain, and the cause which limits the speed of the ordinary chain gear does not exist. The first section of *Fig. 2* shows a new

chain on the sprocket; the second section shows the same chain after having stretched, and illustrates how the chain automatically adjusts itself to the sprocket, remaining always a perfect fit for it; the third section shows the rolling action of the chain as it comes into mesh. There is seen to be no sliding of the chain on the sprocket tooth, which means, of course, minimum of wear and a maximum of efficiency. The Renold Silent Chain Gear, as Mr. Renold has named this development, is therefore noiseless; it can be run at high speeds; and it retains the originally perfect action until worn out. Another valuable property, which is a corollary of the self-adjusting feature of the chain, is the possibility of running two or more chains side by side on the same wheels. In this way, when large powers are to be transmitted and the width of the chain necessarily becomes too great for convenience in manufacture or in handling, several chains may be used with the perfect assurance that each will bear its proper share of the load. This is in great contrast to the known impossibility of getting two ordinary chains to stretch evenly and so distribute the load between them. As the number of chains becomes greater the difficulty by the old method is more than proportionately increased.

The life of a chain is the length of time which it will take to stretch it so much that it ceases to have any bearing whatever on the teeth of the sprocket wheels. A very small bearing will suffice, because the load is divided between all the teeth in mesh. Hence, to prolong the life of the chain, the steel used in its manufacture must be of the very highest grade obtainable, and it must be worked with the utmost accuracy. A steel for the links of high tensile strength allows the use of pins or rivets of large diameter while preserving the tensile strength of the chain as a whole. The large bearing surface so obtained is rendered yet more valuable by the use of hardened pins of high-grade material. The washers on the ends of the rivets claim no little attention. They must be small in diameter and not too thick. This necessitates a steel of high tensile strength and elasticity, so that the washer shall grip the rivet when

it is forced over it and still, by its small size, not add to the bulk nor detract from the appearance of the chain.

From the question of material one naturally passes to the allowable limits of error in workmanship. In a general way it may be said that the chain should be as accurate as it is possible to make it. The pitch must be accurate, and the rivets must be neither so short as to bind the links nor so long as to give excessive play.

The point to be especially observed and emphasized in the above is the fact that the chain remains a perfect fit for the wheel independent of the stretch. This means that an old chain works as well as a new one.

It also means that the engineer can now adopt chain gearing wherever it is indicated or desirable, and is not forced to adopt a substitute or a makeshift because of objectionable noise or because the desired speed is too light for chains.

Before giving a history of the development of the chain it will perhaps be well to indicate roughly the principal fields into which the Silent Chain has found its way.

First and most important comes motor driving. It is no exaggeration to say that the Silent Chain has made the use of motors possible in very many cases, and in countless other cases it has made their use much more convenient.

This is because it provides a flexible means of connecting the power and the work, and one which is silent, positive and efficient. It may be run at high speeds, often permitting the use of a light high-speed motor instead of the more expensive and heavier low-speed machine of the same power.

It makes less noise than spur gearing, does not require short centers, nor need the centers be absolutely fixed.

It may, on the other hand, be used on shorter centers than are possible with belting; and a wasteful and troublesome idler does not have to be provided for. Above all, the speed ratio is positive, as slip is impossible.

Related to motor driving is dynamo driving. It often happens that while space for an engine and generator is limited, the appropriation is also too limited to permit

the installation of a direct connected set. In this case it is possible to install a chain-driven dynamo in but little more space than that occupied by the direct connected set, and at much less cost.

Governor Drives.—The importance of a positively driven governor cannot be overestimated. The difficulty of suddenly accelerating heavy governor balls is emphasized by the wide belts in use on well-known engines. By the use of chain, an absolutely positive, non-slipping drive is obtained and one that is noiseless.

Machine Tools.—The Silent Chain has found large employment, both for use within the tools themselves and for driving them. A little later I will present some slides showing both applications.

A positive drive for feeds is most important, if we wish to get the maximum of work out of the tool. This is being recognized more and more every day, as is evidenced by the advertising colums of the trade papers.

The Silent Chain has been largely used for this purpose both in this country and abroad.

For driving the spindles of milling machines, etc., especially where the feeds are driven independently, the importance of a positive drive cannot be overestimated.

If the cutter is belt-driven, when it strikes a hard spot in the metal, it slows down or stops (because the belt slips), but the feed goes right on with disastrous results to cutter and work. This is not theory but a sad fact, with which many of us are acquainted.

Hardly a machine shop is being put up nowadays that is not electrically driven, and many old shops are being altered from belt-driven to motor-driven.

Here the convenience of the Silent Chain is most manifest, as it permits the easy attachments of motors to tools where their use would be inconvenient if not impossible without it.

Automobiles.—The features of the Silent Chain which particularly recommend it for automobile work are its efficiency and its automatic compensation for stretch.

It one case, there was a gain in effective power on the

rear axle of over ¼-horsepower, due to the substitution of roller chain by Silent Chain, the motor being a 7-horsepower gasoline engine.

The automatic compensation for wear also prevents the chain "riding the sprockets." Silent chain is now in use on hundreds of motor-cars of all types and sizes—both in England and on the continent.

The Silent Chain was by no means a happy thought, but —like almost all other important inventions—is the result of a great deal of hard work and hard thinking by men who have made chain-gearing a life-study.

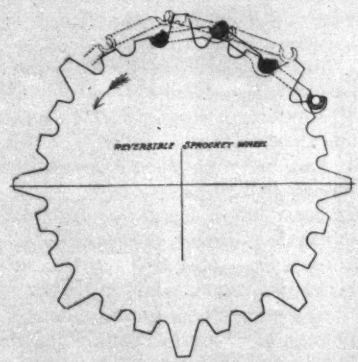


FIG. 3.

As one interesting point in this development, *Fig. 3* illustrates the construction of a sprocket designed some years ago for use with Ewart Link-Belt by Mr. James Mapes Dodge.

The chain on this sprocket compensates for the elongation in the same manner that the Silent Chain does by taking a position farther out on the wheel teeth. This is but another illustration of the often noted circumstance of two men working entirely independently, arriving at the same result at about the same time. It is also interesting to note that this link-belt star sprocket is also a practical success.

The Silent Chain Gear was then the result of a thorough appreciation of the problem to be solved. It was preceded by what Mr. Renold called his "High-speed Block Chain," which was a chain made up of blocks and side-bars with the blocks of peculiar shape. The idea was to get a block shape and a tooth shape such that the block would roll to its seat instead of sliding on the tooth. This was accomplished in great measure, but the difficulties due to chain elongation and wheel wear were, of course, unprovided for.

FIG. 4.

FIG. 5.—"Block" type.

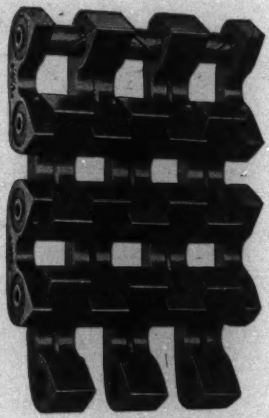


FIG. 6.—"Multiple Block" type.

Last came the Silent Chain. In that form shown on the patent drawings it was impracticable for large powers, and required a complicated sprocket with staggered teeth. This form, however, was rapidly left behind and the present shape of link evolved, which may be used for all powers and which does not require a complicated sprocket.

The chain was originally made from links stamped from the sheet as shown in *Fig. 4*. The rivets were shouldered

and the chains were made in the same pitches and widths as now.

The steel was comparatively soft, and it was necessary to keep the rivet diameter small to preserve the tensile strength of the chain, with a consequent limitation in bearing area on the pin. One obvious remedy was to harden the link. This, however, was not commercially possible, because the burrs left by the punching, which knocked down and did no harm ordinarily, became knife-edges, which cut the sprockets directly the links were hardened. This made it necessary to grind the working faces of the links, which was too expensive an operation.

After several attempts Mr. Renold finally succeeded in getting a bar drawn of the desired cross-section and commenced the manufacture of the Block Silent Chain (*Fig. 5*) and the multiple block (*Fig. 6*). These had hardened blocks, larger rivets and oil grooves.

This type was the highest development up to a short time ago, when it was found possible to further improve the stamped silent chain by the use of harder link stock of higher tensile strength. This permitted the use of rivets larger than those in the block chain, and by a process for smoothing the working surfaces of the links the stamped type again comes to the front (*Fig. 7*.)

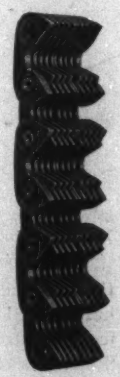


FIG. 7. New flush-side stamped silent.

Steel fully as good, if not superior to any Mr. Renold has obtained in Europe, is obtainable in this country, so that the chains now made here, of which samples are shown, are of as high a grade as possible in every way.

The sprockets used with the Silent Chain form, of course, an indispensable part of the gear. They must be accurately cut with special cutters and may be of any material. The teeth have straight sides to give a full bearing with the working surfaces of the chain. The angle of the tooth is different for every diameter of sprocket; or, to put it in another way, the angle between the sides of the tooth

becomes greater as the number of teeth increases. The limits to the number of teeth that may be employed are practically fixed at 18 and 120. The former limit is set by the fact that in a wheel with this number of teeth the sides of the teeth are parallel. Conversely, when a wheel has 120 teeth, the tooth becomes so blunted as to make slipping a possibility, so that this number should be exceeded only where the load is absolutely uniform.

The fact that the load on the sprocket teeth is distributed over all the teeth in mesh, obviates the necessity of using a metal of high-tensile strength for the sprocket wheels. The fact that there is no sliding of the chain on

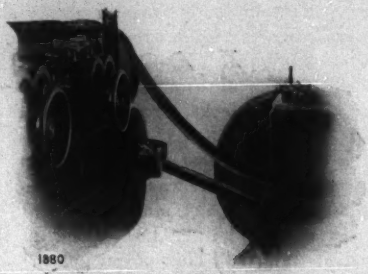


FIG. 8.—40-horsepower motor drive, 720 revolutions per minute. Drives shredding machine. Chain shown in motion. Note smooth action.

the sprocket teeth obviates the necessity of using a very hard metal to minimize wear. It is therefore possible to make a strong and durable sprocket wheel of cast-iron. Steel, however, has been used for the small wheel on automobiles, and in other cases where the service was particularly severe. The flanges are put on after the teeth are cut, and are either shrunk on, or riveted to the wheel.

With regard to the practical use of the chain the following points may prove of interest: It is obviously necessary that one wheel of the pair be flanged to prevent the chain running off; it has been found that better action is obtained where the driven wheel is flanged; the chains may be run with the sprockets so close together as to barely clear, or

the drive may be of any length up to ten to fourteen feet without supporting idlers and, if such support be used, may be of any length found economical and desirable.

The only factor so far found which serves to limit the speed is the difficulty of keeping the lubricant on the chain at very high speeds. At speeds exceeding 1,300 feet per minute, the oil is thrown off by centrifugal force, but speeds as high as 2,300 feet have been employed successfully by enclosing chain and wheels and running them in oil. In this connection, however, it may be well to

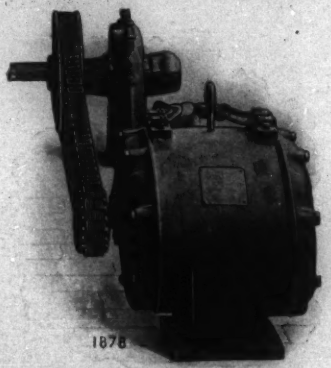


FIG. 9.—1-horsepower motor drive. 690 revolutions per minute. Drives tumbler dumper.

call attention to the fact that the chain speeds being lower than the speeds necessary for belting, allow sprockets of correspondingly smaller diameters for the same angular velocities. The chain thus effects a marked economy of space, not only in the diameter of the wheels, but because of the comparatively long centers absolutely essential with belting. The line of centers may be horizontal, inclined or vertical, provided that the shafts are parallel; but there are two limitations on vertical drives. The small wheel should not be the upper one, because the weight of the chain crowds it into the sprocket and gives bad action. Some

form of tightening device should be provided, either by adjusting the centers or by an idle roller on the slack side of the chain, so as to prevent the chain, when it stretches, falling away from the lower sprocket. Both of these troubles may be obviated by inclining the line of centers.

Wherever the chain gear is exposed to dust or grit of any sort, it should be enclosed in a dust-tight casing. In any case, a light metal guard should be provided to prevent anything falling into the gear.

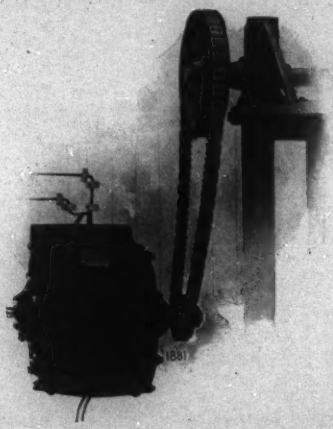


FIG. 10.—7½-horsepower motor drive, 710 revolutions per minute. Drive curing machines.

To sum up.

The Renold Silent Chain Gear possesses, in common with all chain gears, these advantages:

(1) A positive speed ratio (no slip).

(2) No tension in the slack side of the chain and, therefore, a minimized loss in journal friction.

(3) Adaptability to short centers or to long centers.

(4) Adaptability to hot or damp situations.

In addition to these it possesses the following unique advantages:

(1) It is silent.

(2) It may be run at high speeds.

(3) The initially perfect action is preserved throughout the life of the chain.

(4) The load is distributed over all the teeth in mesh.

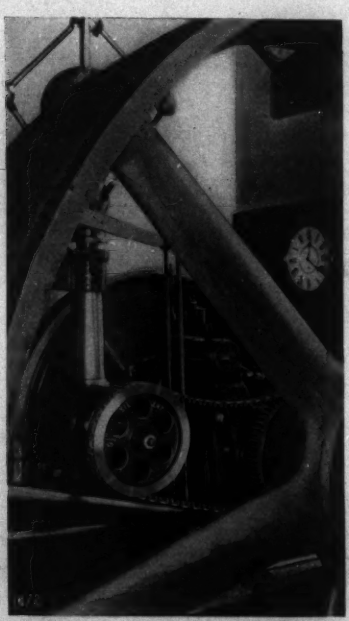


FIG. 11.—Governor drive on 14½ x 24 inches Porter-Allen engine.

It is superior to leather or rubber belts because:

(1) It provides a positive speed ratio.

(2) There is a minimum loss in journal friction.

(3) It can be used in hot or damp situations.

(4) It can be used on short centers without a troublesome and wasteful idler.

It is superior to spur gearing because

(1) It is noiseless.
(2) It does not require fixed centers.
(3) It does not require short centers.
(4) There is no sliding friction on the teeth.
(5) It is smoother in action and generally more durable.

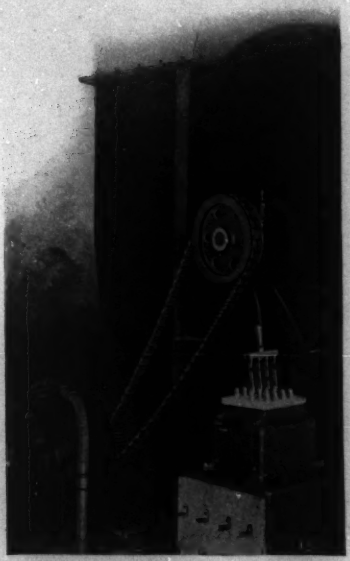


FIG. 12.—10-horsepower motor drive, 710 revolutions per minute. Drives Sturtevant fan.

We will now take up the illustrations of the practical application of the chain.

While the Silent Chain was invented and developed in England, it may fairly be said to be making rapid progress in this country since its comparatively recent introduction.

The largest single installation is that in the new factory

of the Natural Food Company, makers of Shredded Wheat Biscuit, Niagara Falls, N. Y. Here there are nearly forty drives, which vary in size from 1 to 40-horsepowers.

Fig. 8 shows a 40-horsepower drive, motor runs 720 revolutions per minute, and the chain about 1,100 feet per minute. This drives a shredding machine and is one of four similar drives.

The conditions throughout these works are severe because induction motors are employed which start suddenly. No clutches are used, and the sudden stress would be disastrous to spur gearing where the load is concentrated on one tooth. These conditions are easily met by the Silent Chain, however, because the load is distributed between all the teeth in mesh.

As a contrast, *Fig. 9* shows one of two 1-horsepower drives for tumbler dumpers. The absence of special base plates necessary for spur gearing is noticeable.

Fig. 10 illustrates the convenience and adaptability of the chain. The camera was pointed upward, the motor being on the ceiling. It is one of the 14 drives for the curing machines. Motor 7½-horsepowers, 710 revolutions per minute.

The remaining cuts illustrate very well all the various points brought out in the body of the paper.

They are interesting as showing the variety of size and service to which the chain is adapted.

POLLUTION OF STREAMS BY MINING COMPANIES.

The following editorial comments are taken from the *Engineering and Mining Journal* of recent date:

A decision of considerable importance to the coal mining companies of Pennsylvania, especially in the anthracite region, has just been rendered by the Supreme Court of that State. The case has been before the courts for several years, originating in Schuylkill County where the Court of Common Pleas decided against the mining companies, and two appeals were taken, which finally brought the case to the court of last resort.

The suit was brought in the first place against the Lehigh Coal and Navigation Company to recover damages for polluting Panther Creek by flooding the stream with coal dirt and refuse from the mines. The plaintiff in the case owned a grist mill on the stream which he claimed had been injured by the dirt and silt carried into his dam and race, and the lower court awarded $4,900

to cover the injury done. The amount at issue in this case was not particularly large, but as it is a test case which will cover a number of other suits which have been brought or are waiting for this decision, its importance to the companies is very much greater than the number of dollars absolutely at issue.

From an early date it was the practice of the collieries in the anthracite region to run the mine water, carrying with it a very large amount of coal dust and waste, into the nearest convenient stream. Even when the extent of mining business was comparatively small there was more or less controversy over this, and when the collieries became more numerous several of the companies built retaining dams and other works at considerable expense in order to provide places where the coal and dust tailings could be dumped. This was not universally done, however, and much of the refuse continued to find its way into the streams until the waters of the Lehigh, Nescopec, Lackawanna and other rivers throughout the region became thoroughly polluted.

Of late years there has been some improvement in this respect, which was rendered absolutely necessary by the growth of the towns and cities through the anthracite country and the difficulty of obtaining a proper supply of water for them as long as the pollution of the streams continued. In some cases, however, the expenses of the necessary work were paid for by the cities and towns and not by the companies, while at some collieries refuse was dumped on the banks of the streams only to be carried away by the spring floods. The condition, in short, has been unsatisfactory, and the right of the people to the use of the water unpolluted by refuse has not by any means been recognized by the companies.

In this decision the language of the Supreme Court is very clear, and not only supports the decision of the Court of Common Pleas but even goes considerably beyond it. Thus the opinion of the court below held that the injury to the plaintiffs was not permanent and that the dam and race could be cleared of coal dirt at a cost very much less than the water power; but while this point was correct, the very nature of the operation showed that, as it had been conducted, there was practically a continuous interference with the proper use of the water by means of the continued loading of the stream with dirt. It was correct, therefore, not only to assess the damages actually sustained by the plaintiffs, but also to restrain the defendant company by an injunction from polluting the waters of the creek in the manner described in the complaint.

In this case, as in other similar actions, the injunction of the court is the appropriate resort for the prevention of trespasses and nuisances which are persisted in and which threaten to become permanent in their nature. Ample authority may be found for this both in the Common Law and in the statutes of Pennsylvania, and the Supreme Court therefore sustained and confirmed the perpetual injunction against the Lehigh Coal and Navigation Company granted by the lower court. It becomes apparent that if this case is followed up by other suits—as it will be in all probability—during the next few years some of the anthracite companies will be put to considerable expense in providing retaining dams and dumping grounds. In some cases there may be serious difficulties involved in the construction of such works, but that they will be required in the future there is no doubt.

Section of Photography and Microscopy.

Annual Meeting held Thursday, January 2, 1902.

PHOTOGRAPHIC PERMANENCE AND THE AMATEUR PHOTOGRAPHIC EXCHANGE CLUB—1860–64.

By Prof. Charles F. Himes, Ph.D., LL.D.,
Honorary Member of the Institute.

(Being the Address of the retiring President.)

With the very first experiment in photography the question as to permanence of results arose. The process of Wedgewood and Davy failed in practical results, mainly because the pictures were permanent only when examined by artificial light, and even then deteriorated. The question, "How long will it keep?" has been running all through the literature of photography to the present time, and to-day, owing to the wide range in the applications of photography, it is continually recurring in regard to the preparations used, but more especially, in view of the growing application for record purposes, in regard to the final product, the finished print. The question as to the keeping qualities of any of the preparations used in any of the stages of the photographic practice toward the finished print is a very secondary one, except in so far as it may affect the permanence of the print. Whether developers will keep, matters, upon the whole, very little. Their very efficiency depends, in fact, upon their chemical instability. It is only a question of a little more or less trouble, and perhaps a little more expense. So, in regard to fixing solutions, where instability may have graver consequences to the finished print, there need be no room for question, because they can be placed above suspicion by fresh preparation. But how long negative plates or films will keep in good condition before exposure in the camera, and under what conditions, is not simply a question of convenience or expense but of applicability of photography where con-

siderable time must necessarily intervene between their preparation and use, as upon scientific and other expeditions. Closely related to this is the other question, as to the length of time allowable after exposure before development. These questions are, however, of importance, practically only between comparatively narrow limits. An answer to the question as to the years that dry plates will keep in good photographic condition, or whether they will keep indefinitely, has, however, some interest as affording an *a fortiori* argument for belief in and demand for plates that may keep in good condition for any particular purpose. But it is when we come to the print, as has been said, the question assumes its highest importance, a dominant character. All consideration of the photomechanical print may be omitted in this connection. It has a utility and permanence all its own, but, as it is necessarily not strictly photographic, but one remove from the photograph, if it lacks some of the record qualities, especially of minute microscopic rendering of details, it fails, it might be said, in original entry quality of the photograph.

It is not proposed this evening to traverse this question of photographic permanence exhaustively, or to discuss it by means of facts independently and scientifically established, but rather as a question to be determined empirically by means of data of the highest character for authenticity, furnished by one of the earliest photographic organizations —the Amateur Photographic Exchange Club, from 1860 to 1864, composed of men of careful habits of systematic work and observation, many of high scientific attainments.

As preliminary, it may be well to fix definitely what is meant by time-effect in this connection. Time is recognized as so necessary a factor, that it has almost come to be regarded as capable *per se* of producing changes, or that some things will change, perhaps all things deteriorate, simply with lapse of time. Now a time effect *per se* is inconceivable, and we are justified in any case of, what for convenience may be called photographic change, in looking for some cause as fully as we are justified in mechanics in assuming a cause where a body changes its state of rest, or

of uniform motion in a straight line. These causes of change in sensitive films, and other photographic preparations, may be internal or external, or a combination of both. They may be minute, feeble, operating slowly but with cumulative effect through a very long time. There may be in some cases molecular movements in a sensitive film that will gradually change its photographic character. There are many analogies, physical and chemical, to suggest it. In a supersaturated solution of a salt, crystallization may take place rapidly, but gradually enough to be watched, and just as such crystallization can be started by an external mechanical impulse, so, it is conceivable, external causes, changes of temperature, vibrations of all kinds, even jarring of floors and buildings, may assist, even if they do not originate, molecular changes that may affect the whole photographic character of a film.

Perhaps a more analogous case is that of the slow crystallization of axles, wheels, bolts, cannon, and so forth by jarring. We are familiar, too, with what is called the "continuating action" of light, and it is a question whether sufficient allowance has been made for this fact in accounting for deterioration of films, and papers exposed even to a very feeble light during preparation in drying. Experiments made upon papers, though not as decisive as could be wished, seemed to substantiate this view. Again, well-defined chemical reactions, as experience in the laboratory shows, require time, and in many cases prolonged time, for perceptible result, and such may be taking place slowly in a sensitive film, and eventually affect decidedly its character. When, further, all that is covered by the term atmospheric conditions, normal and abnormal, is taken into consideration we have a legion of possible agents operating to change photographic preparations and products. Now, the fact to be recognized is, that all these conditions are matter of observation and investigation, and in many cases may be eliminated or neutralized, as the great advance in certainty and keeping qualities of plates and papers in the past few years shows.

In investigation of such conditions a natural tendency to

give, perhaps, undue weight to established chemical reactions may cause minute subtle conditions to be overlooked, accompanied by a conscious or unconscious assumption that highly sensitive photographic compounds are in their very nature sensitive to other physical and chemical agencies than light; that they are in short in their nature wanting in permanence, in spite of the fact that silver chloride, bromide and iodide are amongst the most stable chemical compounds, so far as other agencies than light are concerned. An over-caution resulting from this want of faith in photographic preparations often manifests itself in *à priori* conclusions, and positive, scarcely tested statements, and a time-limit has been fixed entirely unwarranted, and once fixed is apt to maintain its place. As a little illustration, it was stated by some one that blue-print sensitizing solution would not keep; it became permanently incorporated in photographic literature, and there it remains in spite of published statements, again and again, that it will keep unimpaired for years, and many may be deterred from its use by this positive charge of instability. Time has in very many cases, then, doubtless, been made the scapegoat for many avoidable causes of photographic deterioration, for imperfect knowledge or oversight of conditions, for unscientific or careless work, for improper treatment, and storage, etc. The survival of one specimen in excellent condition is sufficient to establish permanence of any method, and direct investigation to the causes of deterioration with certainty of success in discovering and combating.

Considerations such as these suggested that the objective presentation this evening simply of some well-authenticated facts in this connection might not be without general interest, and at the same time recall some of the pioneer workers of your city. As to the keeping qualities of gelatino-bromide plates, it may be well to recall a partial report made at a previous meeting of this section. Reports upon this point have been exclusively made upon plates that have remained unused by accident, and not upon those carefully tested and deliberately placed aside for this purpose. One or two failures with plates kept longer than

usual, ascribed to their age, served to fix a time-limit beyond which others were not permitted to go before use, and unused ones would not be likely to receive much care. Unopened dozen boxes out of gross boxes of plates, by Cramer, Inglis, and Eastman, in my possession since 1884, were furnished to this Section and to the Philadelphia Photographic Society to be tested. Plates from the same lot had been tested at different intervals since that date by myself and others. The results were generally as satisfactory as with the plates originally. The plates at that time had not the rapidity of plates subsequently prepared, and it is not possible to say positively whether there was any loss of sensitiveness with age, but there did not seem to be.

According to report made by Mr. M. I. Wilbert to this Section, with the accompanying negatives upon the Cramer plates exhibited here, they seem to have been in as good condition as when first received fourteen years before. By a singular coincidence, illustrative of what has been stated, whilst these old plates were establishing the permanent excellence of the Cramer plates, that maker was advertising the innovation of affixing to packages of all plates sold the time-limit within which they would be guaranteed, and there was expectation on the part of some that this lead would be followed by other makers. But the advertisement has disappeared. An interesting report upon plates submitted to the Philadelphia Photographic Society by its technical committee is published in its proceedings,* with full discussion, including the effect of mode of packing the plates. Whilst the lot of plates at their disposal seemed to manifest a a greater tendency to fog, this may have been due in part to shorter exposure and energetic development, as the plates, although the most rapid of that date, were not as sensitive as those of to-day. These plates at the time they were submitted were, with reason, believed to be the oldest authenticated non-exposed plates, and are, probably, of gelatino-bromide plates; but in the course of the evening, in connection with other matters pertaining to the club

* *Journal of Photographic Society of Philadelphia*, Vol. V, No. 6.

already alluded to, prints will be laid before you from negatives made upon plates so much older before exposure that the importance of the preceding ones will be reduced.

A word in regard to the origin and character of the club will serve to show the basis of reliability for data furnished by it. Its history, carefully written by Coleman Sellers, now Doctor, was published several years ago,* and it will not be necessary, therefore, to go into details as fully as might be otherwise desirable. It originated in a desire on the part of some amateurs to obtain copies of a peculiarly good stereograph of a "cattle picture," taken by Robert Shriver, of Cumberland, Md., without actually begging the pictures. They proposed, therefore, to exchange pictures of their own for them. At the suggestion of H. T. Anthony, not then a member of the firm, but an enthusiastic amateur, a club was formed, limited to twenty, without formal constitution or regularly elected officers, or form of election of members, all matters being regulated by correspondence and common consent, with most perfect harmony. Among the rules were the following:

"(1) None but amateurs in the art shall be recognized as members, and the number shall not exceed twenty.

"(2) No member shall forward for exchange any work not his own.

"(3) Every member shall forward each other member on or before the 15th of January, March, May, July, September and November, at least one stereoscopic print, a copy of which has not been sent before, or its equivalent mounted and finished.

"(4) Should any members desire to exchange with any others oftener than bi-monthly, they can do so by agreement.

"(5) Any one failing to send one print bi-monthly shall be struck off of the book of the party he so fails to send to, unless satisfactory reason is given for his default.

"(6) All photographs must be properly labeled with a descriptive name, the name of the artist and the date of the

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* *Anthony's Photographic Bulletin*, 1888.

printing, and they must be guaranteed not to fade for two years; and if toned by experimental process, must be marked 'Experiment.'

"(7) Two unmounted prints shall be equivalent to one mounted and finished of the same size. Two-card or quarter-plate shall be equivalent to one stereoscopic, and two stereoscopic to one whole plate."

Among the members were H. T. Anthony, Lewis M. Rutherfurd, the astronomical photographer; F. F. Thompson, of Wall Street, Augustus Wetmore, C. Wager Hull, John M. Masterton; Prof. O. N. Rood, the eminent physicist, Professor Emerson, of Troy; in Philadelphia, Constant Guillou, Coleman Sellers, F. T. Fassitt, S. Fisher Corlies, Prof. Fairman Rogers, E. Borda, Dickerson Sargent; in in Washington, Tition R. Peale, and Rev. Dr. Charles Hall; in Pittsburg, Capt. T. J. Brereton; in Cumberland, Md., Robert Shriver; in Boston, Dr. John Dean, and in Baltimore, George B. Coale, and others perhaps in the later years, as the rule in regard to numbers readily relaxed to admit a desirable additional member. The exchange prints in possession of each of the members of that club constitute unique collections in the character and variety of the subjects and workers, and are perhaps the best authenticated prints of that date, with reliable data, on many desired points. The specimens presented for your inspection were taken, almost at random, from my own collection. They will be found generally in most excellent condition, showing no more the effect of time than a collection of engravings might do. They have been kept, not with very special care, in pasteboard boxes, and have been handled in use as stereographs, perhaps more freely than ordinary photographs.

Prof. O. N. Rood, for many years of Columbia University, New York, writes: "A short time ago I examined all my old photographic prints and found them in perfect order; I also examined the prints received from members of our club: they were as good as new. But I have photographic portraits of Dr. John Torry, the chemist, and of Dr. B. A. Gould and others, that have nearly faded out, though not nearly so old as ours."

Robert Shriver, President of the First National Bank, Cumberland, Md., reports his, so far as yet in his possession, in good condition, exceptions due to bad washings and hypo. Dr. Coleman Sellers states "a great many of these are in an excellent state of preservation, running uniformly through the work of the various members of the club, and they have not been given any special care other than that they have been kept in separate cases and labeled, the cases being open at one end."

F. T. Fassitt reports that prints on albumen paper afford greatest claim for permanency. Prints made of the Sanitary Fair, 1864, hung exposed to changes of light and weather in his library since then, have retained all their brilliancy without the least sign of deterioration.

But there was a great deal done by members of the club, outside of the rules and simple exchange of prints, in way of exchange of ideas and experience, with permanent results in some cases upon photographic practice. Thus alkaline development of dry plates was first suggested by Borda in place of the universally practised acid development. The great problem of that day was the production of a dry-plate process that would equal in rapidity and results the collodion wet-plate process, and require the minimum of trouble in practice. The virtues of beer, solid milk, albumen, tannin and many other substances were tested and reported upon. The tannin process seemed to be the survival of the fittest. In this connection Borda also suggested warm development. Many of the prints exhibited are from tannin negatives, and the negatives and stereographs on glass by that process show its possibilities. It is exceedingly simple and certain, and, according to a method contributed by myself, plates can be prepared up to the last stage, of flowing with a solution of tannin—fifteen grains to ounce of water—in broad daylight. But a far more interesting fact, just put in my possession, bearing on photographic permanency, are the prints, here exhibited, from tannin negatives, on plates prepared in 1863 and exposed in 1898. The plates made by him—Mr. Shriver writes—"had been hid away in an outer room, where they were subjected

to extremes of heat and cold, but were kept perfectly dry. They come up in development as good as I could have expected if the exposure had been made in 1863, instead of thirty-five years later." The prints exhibited will be found to compare favorably with those from the best gelatine dry-plates of to-day. He adds very pertinently: "Here, then, was an answer to the query, 'How long will dry plates keep?' Good for thirty-five years, and perhaps indefinitely, if made by the 'tannin' process." Apropos at this point is an interesting experience of Dr. Coleman Sellers in regard to the permanence of the impression in the camera before development. A dozen tannin plates furnished by him to a friend were returned in three weeks as exposed. After several had given no results upon development, he re-exposed one of the plates and obtained an excellent negative. From a series of experiments, subsequently made, he concluded that between the time of exposure and development every day that intervened diminished the chance of success. He regards the effect of exposure "as a strain put upon the parts of the film according to the intensity of the light that fell upon each particular moment of surface, but this strain would gradually be relaxed if not fixed by an immediate development, and there was no chemical action on the plate, but mere physical action that was temporary in its character." To return to the club prints—and among these are included some by Joseph M. Wilson, of the same period –they will be found to be exclusively on albumen paper, and, except when marked experimental, as a rule toned in alkaline gold bath, and fixed in separate bath. The paper in many, perhaps most, cases was albumenized by the members themselves, as commercial albumen paper in early days was not as uniform in quality as at present, and poor prints were apt to be attributed to the paper, and often with right. Many of the members of the club had the advantage, several years before its publication, of one of the greatest improvements in albumen printing imparted to them by H. T. Anthony, namely, the fuming of the well-dried sensitized paper with ammonia. It eliminated many sources of failure. Considerable variety

of tone and of surface is observable in the prints: some are somewhat discolored, but few more so than a collection of engravings under the same circumstances would exhibit, whilst very few show symptoms of fading, and in slight degree. The print of the full-moon, by Rutherfurd, it will be noticed, shows no discoloration or change of any kind, whilst the white mount has very perceptibly discolored.

It has hung, framed, in a well-lighted room for years. In some prints little specks of mold appear upon the face, which can be rubbed off without apparent injury to the print. This seems to originate in the paste, as the labels on the back in some cases show the same effect, even when the prints are free from it. The mold does not necessarily involve the albumen of the print. The portrait shown, which hung upon a damp wall, was half of it loosened from the mount by a mass of mold, and yet, at present, scarcely shows the outline of it, after being soaked off from the mount and thoroughly washed. In the selection, readily made, from a collection of commercial prints of the same date as those of the club, many will be seen to have almost faded out of sight, among them some by makers justly of highest reputation, as Langenheim, of Philadelphia. These might be explained as toned with the old combined bath before its bad character had been established. Of the foreign views the French have deteriorated most; and the Italian, of which least was expected at the time, show less change; and the English and German are as a rule well preserved. The collection shows that albumenized paper can be made to yield results not only unsurpassed in beauty of tone and rendering of the best qualities of the best negatives, but, with proper care in the production, unchanged after forty years, and promise of remaining so for forty years to come. A first-class albumen print may then, indeed, at present be regarded as the standard of permanence, not on *à priori* ground, but as an experimental fact. The departures from permanence exhibited may be explained in many cases by the defects and uncertainties of the process at that early period, now eliminated, and in other cases by the want of care at all stages, especially in toning and washing. The

uniformly high permanence of the club prints may be attributed to the character of the workers, their extreme care in manipulation and in the processes employed, and the limited number of prints made at a time, which made greater care possible. There is no argument in this for a return to albumen paper but surely a suggestion, that for record purposes albumen prints might well be included with those of platinum and carbon, which are so generally exclusively recommended or demanded. The practical lesson of the prints is that permanence is perhaps not so much a matter of process as of conscientious care in carrying out the conditions necessary for permanence with any process. Even the blue-print process, in the specimens here exhibited, that have been exposed to light and many conditions unfavorable to permanence, compares favorably with the best processes in this respect, whilst the platinum prints, with pure whites, when made about twenty years ago, show discoloration, due most likely to the paper. This simply shows that it is unsafe to argue too far on *à priori* grounds from the permanence of platinum as a metal to the permanence of prints based upon it, where so many complex conditions are involved, conditions still matter of discussion by Chapman, Jones, Haddon, Jacoby and others, in explanation of admitted deterioration of platinum prints in some cases. The duplication of prints for record purposes by several of the most approved processes, made by persons of established character for conscientious care in printing, with a record of the essential details of the process employed in each case, might contribute something to the character of the record.

The albumen process, as the prints show, has no superior for photographic expression, rendering all the good qualities of a negative. It is a perfected process: simple, easy, not more troublesome than any printing-out paper, and with little practice, certain in its results. Its fine surface is not easily abraded, and it permits warm solutions and warm water at all stages without the least risk of injury. The paper ready for sensitizing is a commercial article of uniformly excellent quality. It is without offensive gloss. Matt and glassy albumen paper, ready sen-

sitized and of good keeping qualities, have been recently advertised by a German firm, and have been commented on favorably for certainty and excellence of results, said not to be distinguishable from those of platinum. The demand for albumen paper in this country, according to a reliable estimate, is only about five per cent. of that of ten years ago. Its use is confined to those who still demand it, and to cheap commercial work on a large scale, in this; especially stereographs.

The loss of popularity is due in part to the requirement of negatives of the highest class, and in a measure adapted to it. Negatives that might yield very valuable prints with some of the more recent papers would be absolutely worthless with albumen paper. The developing papers, too, permit practice of photography by many who would otherwise not find time to indulge in it, and economize time for the professional. It is in connection with record work, however, that albumen paper has some claim to be considered.

ELECTRO-PLATING BATHS.

M. Jules Meurant, of Liége, Belgium, in a recent patent describes a series of baths for the electro-deposition of zinc, tin, nickel, copper and silver, the characteristic feature in all cases being the addition to a neutral or alkaline solution of the metal, of an organic non-electrolyte, generally a carbohydrate, and in the majority of cases a polyatomic alcohol or derivative. The chief interest of the patent is in the bath described for the deposition of adherent coatings of zinc upon steel. This solution is formed by precipitating zinc from its chloride solution as carbonate, redissolving in ammonium chloride, and adding for each kilogram of zinc chloride taken, 300 grams of gum arabic or equivalent amounts of sugar or glucose. The patentee states that steel tubes coated with zinc from this bath were successfully submitted to the following tests preparatory to their acceptance by the Dutch Navy: (1) Crushing to completely flatten the tube; (2) folding the flattened tube upon itself; (3) crushing a ferrule cut from the tube in the direction of the axis of the cylinder; (4) elongation test of 27 per cent.; and that the protecting layer of zinc showed no alteration either by scaling or breaking. Zinc baths containing carbohydrates are well known in the art, having been patented in France by Blas and Miest, in Germany by Kaselowsky and Basse, and in this country by Frauenfelder and Meyer; the claims of the present patent are limited, therefore, to the specific procedure in preparing the electrolyte.—*Electrical World.*

Section of Photography and Microscopy.

Stated Meeting, held Thursday, March 6, 1902.

A PHOTO-MICROGRAPHIC DEVICE.

By Frederic E. Ives,
Member of the Institute.

Photography, as a means of recording scientific phenomena, is more used and appreciated every day, and would no doubt be more used than it is if all investigators were fully acquainted with its capabilities and equipped to obtain satisfactory results without unnecessary expenditure of time and labor.

Take, for example, the production of photo-micrographs. Probably most people who use a microscope would like occasionally to fix the image which they see; yet comparatively few do so, because it is generally believed that successful photo-micrography involves the exercise of exceptional skill and experience, special and expensive camera devices, rearrangement of microscope and illumination, in positions comparatively difficult to accommodate one's self to, and much time lost. Undoubtedly there is much truth in this, as photo-micrographs are generally made. It is true that a very small and light camera can be attached to the tube of the microscope, over the eye-piece; but under these conditions the amplification in the photographs is much less than it appears in the microscope, and the optical conditions are not of the best.

After making a series of photo-micrographs in the usual way, with the microscope on a special stand and the tube disposed horizontally, I recently set myself the problem of providing for the reproduction of the image observed in the ordinary use of the microscope, without any readjustment whatever, without touching the microscope or even re-focusing. I made the conditions that nothing should interfere in the slightest degree with the comfortable use of the microscope in the usual way; that it might be used

at any desired inclination or tube-length, and with any convenient source of light; that the adaptation and removal of the camera should occupy very little time, and that the amplification in the photograph should always correspond to that in the microscope.

After some study I set to work and managed, with a box-lid, two small shelf-brackets, the bed and rack of an old 4 x 5 camera, a box originally made to carry some 2½ x 3 plate-holders, a 10-inch focus lens, and some minor odds and ends, to produce the device which I now bring to your notice, and which fulfils all of the conditions I have named.

To commence with, we have the box-lid, a clamped piece of ½-inch mahogany, about 10 inches wide and 12 inches long. The microscope is used on this as a base, on which it is held in place by stops against which it is pushed. This base is necessary to provide a fixed support for the camera attachment without touching the microscope itself. Next we have one of the small shelf-brackets, securely attached to the baseboard on each side of the microscope, in such manner that one of the screw-holes in the end comes exactly opposite the center of the joint of the microscope. They are separated just sufficiently to clear all the working parts of the microscope. The screw-holes in the brackets are the points of attachment for the camera device, and must occupy such a position in order that the camera may swing from the same center as the microscope body, and thus be adjustable by a single movement for any desired inclination, from horizontal to vertical. On a double pillar microscope, and even on the Swift portable which I am using, the camera attachment could be adapted to swing from the centers on the microscope itself, and the special base and brackets thus dispensed with; but with the usual horseshoe base "continental" stands the bracket supports are necessary. The total height of the bracket supports for a Bausch & Lomb "BB" stand is not over 3½ inches, and they are not in the least in the way of anything one ever wants to do with a microscope. A detachable double upright can, however, be used, if preferred, and fastened to the microscope base at a moment's notice.

The camera is a simple box, with a lens at one end and fitting for a plate-holder at the other—the lens of 10-inch focus, and the distance from the lens to the sensitive plate, 10 inches. This length of camera insures an image having the same amplification that would be calculated for that in the microscope, provided that its lens occupies the normal position of the eye above the eye-piece. The 10-inch camera and lens are used on the assumption that the position of the objective and eye-piece cannot be altered without altering the character of the image; that the rays forming each pencil of light emerging from the eye-piece are parallel to each other when the microscope is focussed, and that the camera must, therefore, focus parallel rays in order to make a sharp image of the microscope projection at the focal plane without re-focusing the microscope. This assumption is correct under certain conditions, which I shall specify later.

I did not have a 10-inch focus lens, but had 12-inch and 60-inch plano-convex lenses. A pair of these cemented together made a crossed lens of about 10-inch focus, and I mounted it in an old view-lens tube, so that the flattest side comes towards the eye-piece, but an inch back from the eye-point, when the mounts almost touch each other. I should not have used this lens mount, because, although it does not affect the focus upon the ground-glass to move the lens back from the eye-point, it does alter the size of the image by bending the outer pencils of the cone of light in towards the middle. One should either use a double-convex lens at the eye-point, or a lens of longer focus above the eye-point, in combination with a correspondingly longer camera, in order to keep the amplification strictly correct.

On general principles, I would not select a non-achromatic lens for this purpose, and do not recommend it; but it happens that with some achromatic objectives and huygenian eye-pieces a non-achromatic lens gives the best projection. It does not make much difference whether it be achromatic or not if monochromatic light is used for photographing, which is what I recommend with this method of working. The fact that objective and eye-piece combinations do vary

somewhat in this respect makes it a safe rule to photograph with approximately monochromatic light of the brightest part of the spectrum, thereby insuring definition equal to that seen in the microscope.

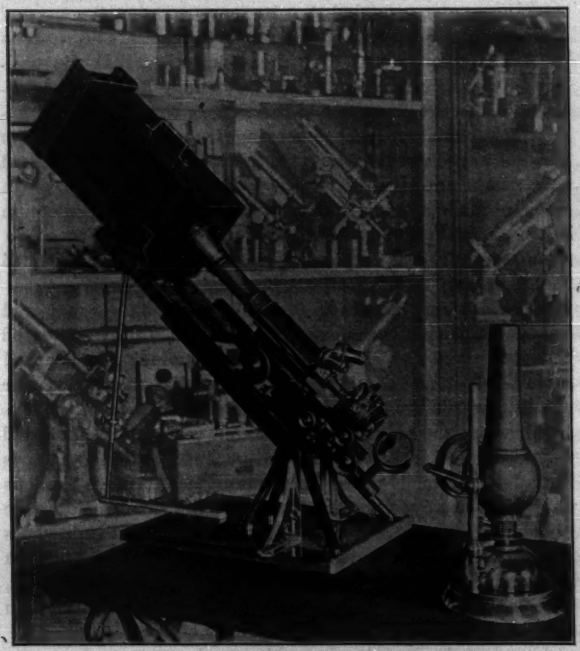

Photo-micrographic camera adapted to a Swift Folding microscope, used on a special base with brackets.

The camera has a rack and pinion movement on a base-board having two rigidly attached arms extending forward, and carrying pins to engage in the screw-holes of the brackets. I have cut slots into the screw-holes, so that the pins drop into place, and provided an automatic lock which

prevents the pins from being lifted out except when the camera is swung below the horizontal plane. An adjustable telescopic strut and detachable extension to the baseboard supports the camera and fixes it at any desired inclination. It is in alignment with microscope tube when the camera lens-mount and the eye-piece are concentric with

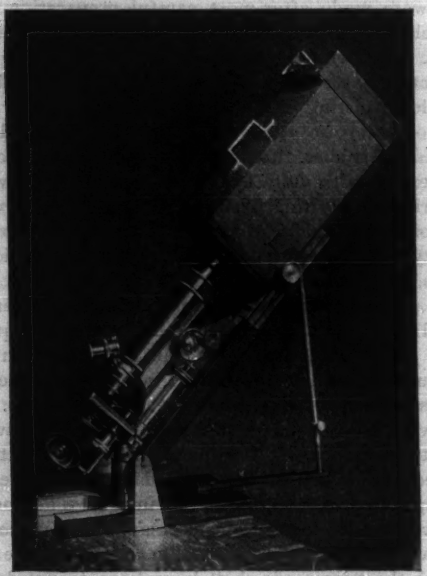

Photo-micrographic camera adapted to a Bausch & Lomb "BB" microscope, with detachable bracket support.

each other when brought together by the rackwork. For optical reasons, strict alignment is far less important than it would be with a camera containing no lens.

It takes me from twenty to thirty seconds to attach the camera and adjust ready for an exposure. A color screen is then [usually] placed between the source of light and the

microscope mirror, admitting approximately monochromatic light of such color as the objectives are best corrected for. Plate-holder is then inserted, and exposure made, using an isochromatic plate.

Photo-micrographs made in this way, ranging from comparatively low amplifications up to 1,500 diameters, cannot be distinguished in character or quality from similar ones which were made after most careful preparation with far more elaborate, expensive and troublesome photo-micrographic apparatus.

Heretofore, I have done this work on a specially heavy table, legs resting upon rubber buffers, heavy marble top also resting on rubber buffers, an inch-board resting on coils of rubber tubing. Without these precautions, I had trouble with vibration when the microscope was used in a horizontal position. I have been using the new device on an ordinary table, and have been surprised to find no difficulty whatever with vibration, so far. The microscope appears to be far less sensitive when inclined at approximately 45° angle than when either horizontal or vertical. I exposed two hours on an amphipleura with oblique light from a Welsbach burner, and the lines came out sharp. Most subjects, with central light, require only one to five minutes' exposure, using rapid isochromatic plates.

I have stated that one of my objects was to avoid the necessity of re-focusing the image, which is objectionable, both because of the time it takes and because it alters, however slightly, the character of the image. The conditions under which no re-focusing is necessary are, that the camera lens shall focus parallel rays at the focal plane of the camera, and that the microscope shall have been focussed with an eye that focuses pefectly parallel rays upon its retina. Under these conditions, the rays forming each pencil of light emerging from the eye-piece are parallel to each other, and will therefore come to a perfect focus at the focal plane of the camera. If the microscope were focussed by a short-sighted or an abnormally far-sighted eye, the rays forming the emerging pencils would not be parallel to each

other, and therefore would not come to a perfect focus at the focal plane of the camera.

Huygenian eye-pieces, and some others, are calculated for an eye that focuses parallel rays, and cannot give the best results to either a short-sighted or an abnormally far-sighted eye. A short-sighted person sees an image which is formed above the correct plane in the eye-piece, and an abnormally far-sighted person sees an image which is formed below the correct plane. A person having theoretically normal sight will focus the microscope correctly, not only for the best image obtainable, but for the focal plans of my photo-micrographic camera. Any one whose eye is not theoretically normal will have to re-focus on the ground-glass of the camera when using low powers; but when he has done so, the image will be exactly what it should be. My own eyes are short-sighted, and in pursuit of my object I have as nearly as possible overcome this difficulty by providing myself with a compensating lens in a mount which fits loosely over the eye-pieces of the microscope, and makes my vision, for the time being, theoretically normal. As this lens belongs to my eye, and not to the eye-piece, I remove it after focusing. This procedure is equivalent to wearing spectacles adjusted for clearest vision at very great distances, which any one may do; but the eyes of very young people, with great powers of accommodation, may not even then be trusted implicitly when working with very low powers. With high-power objectives and eye-pieces, hypermetropes, emmetropes and moderate myopes focus practically all alike.

This new outfit is not calculated to supersede some of the very elaborate and expensive photo-micrographic apparatus and devices which have been produced by Zeiss and others for some special purposes. It will not produce photographs of large size, such as can be made with projection eye-pieces and very long cameras, nor include wide angles of view in low powers, such as may be obtained with Zeiss planar lenses without eye-pieces; but it should be far more generally useful, because it can be relied upon to reproduce clearly whatever detail the eye sees in the microscope, and

with the least possible cost, either in time, labor or expenditure for equipment.

It will be evident that the same camera and procedure as to focusing is adapted to making records with telescopes, spectroscopes and some other optical instruments.

ELECTRICITY DIRECT FROM COAL.

The latest of the many indefatigable attempts made to obtain electricity direct from coal is that of Hugo Johe, of Chicago. He has obtained the patent on a new battery. In his invention a retort is employed, which is surrounded by a cylindrical case containing a battery of four cells. The furnace gases from the retort circulate against the inner side of the cell and case.

Partitions of porous coal divided each cell into three sections, containing respectively nitric acid, sulphuric acid and ferric chloride solution. In the nitric acid an electrode is immersed, and in the narrow chloride solution a lead electrode.

The operations are as follows: A suitable quantity of sulphate of lead is placed in the retort with a quantity of coal nearly sufficient to reduce the sulphate to sulphide, and the mixture is then heated until all of the coal is oxidized. The sulphide is freed from impurities which may have been brought into it by the coal, and is then mixed with sulphate of lead in sufficient quantity to yield metallic lead and sulphur dioxide, which reduction is effected by again applying fuel heat to the retort. The sulphur dioxide passes through a pipe into the larger section of the several cells, reducing the ferric chloride therein to ferrous chloride. Previous to this the generation of the electric current is started by putting the lead electrodes into the larger section and suitably connecting them with the carbon electrodes. The current may be considered as consisting of two currents, one generated by the action of the ferric chloride of the lead electrode, and the other by the action of the nitric acid through the interposed porous walls, and sulphuric acid by means of molecular exchange of ferrous chloride. The flow of sulphur dioxide is so regulated that the sulphuric acid formed is not more than sufficient to decompose the chloride of lead formed in the battery reaction. The lead in the retort is allowed to flow into a pan, where it is suitably shaped or solidified for an electrode. The sulphate of lead deposited by the battery is allowed to accumulate, and at intervals is drawn off by means of siphons, and the deposit of sulphate of lead electrode removed. The temperature of the battery is regulated so that the nitric acid which enters into the sulphuric section is evaporated, the vapors being passed through a condenser and there condensed again to nitric acid, flowing back into the nitric acid sections through a pipe. This process of distillation, oxidation and condensation is kept up by regulating the temperature of the battery and supplying sufficient cooling water to the condenser. Thus oxygen is supplied to the nitric acid, while the generation of electric energy with consumption of oxygen goes on. The E.M.F. of the cell at 100° C. is said to be about 1·75 volts.—*Scientific American Supplement.*

Mining and Metallurgical Section.

Annual Meeting, held Wednesday, January 8, 1902.

A REVIEW OF RECENT PROGRESS IN THE MINING INDUSTRIES OF THE UNITED STATES.

By F. Lynwood Garrison.
Being the address of the retiring President.

Since it is the custom of the retiring President of our Section to present to you an address of this meeting, I have chosen for my theme a short review of the progress and notable changes that have taken place in the mining industries of the United States, during the past one or two years.

It is obviously impossible for me to treat so large a subject exhaustingly in a paper of this character, consequently many interesting matters must be passed unnoticed.

Of all the mining and metallurgical industries, the most notable advance evidently has been in those relating to coal and iron, which to-day exhibit a degree of prosperity that would have been thought impossible ten years ago.

The present highly active condition of all our manufacturing industries have resulted in an unprecedented demand for fuel, taxing to the utmost the railway facilities for delivering it to the consumer, though there is apparently no difficulty in mining all that is required. This statement, however, needs some qualifications in its application to the anthracite coal production. In 1900, the output of this class of fuel was considerably less than in 1899, and when the figures for 1901 are available a further falling off is likely to be observed.* A result of this has been a continu-

* Statistics to hand since writing the above shows this is not the case, the production being for

	Tons.
1899	47,665,203
1900	45,107,484
1901	53,386,271

It is unlikely, however, this increase will continue, or the production for the past year hold its own, unless the present exceedingly prosperous and stimulated condition of business continues.—F. L. G.

ous displacement of anthracite by bituminous coal, with a consequent appreciable increase in the smokiness of the atmosphere of our large eastern cities.

Whether or not the increased price of anthracite is justifiable, in view of the economies and improvements in up-to-date mining, is a question I cannot undertake to discuss. We must consider, of course, that as the deposits are worked out deeper mining is necessary with its consequent greater cost and difficulties in haulage, ventilation and drainage. I do not believe the best of modern machinery or methods can on the whole overcome these difficulties sufficiently to permit the mining of anthracite coal as cheaply as it was produced ten years ago. There is no doubt that in Philadelphia, for instance, we are paying more for anthracite than is just and fair. This is due chiefly to the freight charges, and such extortion benefits the railway rather than the miner. If such conditions check production, they are not an unmixed evil, for, we must remember, the Pennsylvania anthracite fields are relatively small and are being rapidly exhausted.

A notable feature of the bituminous coal industry is the disposition to consolidate the interests involved in its production. This is especially true in what is known as the "Coking Coal Fields," and it is evident that the iron and steel producers are looking far into the future for the purpose of making sure of their fuel supplies for many years to come. While the Connellsville deposits are not yet exhausted, it appears from the best available information that they cannot last much longer, hence other districts must be, and are now being, rapidly developed to meet the ever-increasing demand for coke.

A much more serious difficulty facing the steel worker is the steadily increasing difficult of obtaining iron-ore. The demand has grown so enormously, that it would seem likely, at least in Pennsylvania, that we will soon be as badly off in this respect as the British steel manufacturer, and will have to bring our ores from over the sea. The Lake Superior iron-ore deposits are justly considered the largest in the world; but it seems likely that their superficial limits have

been about determined. Persistent explorations north of the Canadian boundary line have thus far failed to realize expectations, and the hopes of finding an extension of the Minnesota deposits into Canadian territory are by no means bright. In the case of manganese ores a condition has been reached wherein we are largely, if not chiefly, dependent upon foreign sources of supply.

When we consider that the steel industry in this country is not yet fifty years old, and the leaps and bounds with which it is growing, the question forces itself irresistibly, can this pace be maintained? It is true, just as in the case of the basic process, that new inventions will doubtless render ores available which under the present conditions cannot be used, as, for instance, those containing appreciable quantities of titanium and the iron-sands of certain localities. It is now possible to concentrate by magnetic methods, lean and silicious ores heretofore considered unfit for use. Such methods, however, necessitate the comminution of the ore, a condition possessing serious objections when such concentrates are used in a blast-furnace. But these supplies would be a very small proportion of the enormous quantities required, and with our present knowledge of the country's mineral resources it is difficult to see where they are to be obtained. One hundred years is but a short space in a nation's life. Our once seemingly inexhaustible timber supply is rapidly nearing the end, and the nation is but 125 years old. Ores, unlike trees, cannot be cultivated and reproduced; deposits once exhausted are done for all time. We will be told to go deeper down into the earth; but as every experienced mining engineer knows, this is fallacious. Mineral deposits do not extend down into the earth indefinitely, and with the rapidly increasing improvements in machinery these limitations in depth are not likely to be beyond reach; in fact, in the great majority of cases they are so even now.

Since the demonitization of silver in the United States the production of gold all over the world has steadily increased. In this country many deposits previously regarded as silver mines are now denominated gold pro-

ducers; not because the silver has been replaced by gold, but simply owing to the fact that with improved methods and economics it has been found that the contents of gold in the ores has been ample to overcome the decreased value of the silver. It is doubtful if, as a general thing, those silver-producing sections of the country that were the most ardent upholders of the bimetallic monetary doctrines are to-day any less well off than five or six years ago before the great decline in the value of silver. It is, of course, perfectly true that there are some sections where inaccessibility and cost of transportation have made it impossible to operate many silver-lead deposits previously profitable. Such ores, lacking the redeeming gold element, must await more favorable conditions, which are certain to come with the development and settlement of the country.

The use of electricity generated by water power is becoming very general in sections where fuel is expensive. The great improvements made in tangential jet water wheels have resulted in economics hitherto not supposed possible, with the result that many low-grade mines can now be operated that were previously unprofitable to work.

The introduction of the cyanide process has been a great boon to the gold-mining industry. We have been slow to adopt it in this country, and its merits are even yet by no means fully realized, nor its limitations reached and understood.

On the whole, conditions have never been so favorable to the economic extraction of gold from its ores, and the exploitation of many of our low-grade gold-deposits constitute to-day some of the best opportunities for legitimate mining that has ever existed in the world. Investments in enterprises of this character are probably safer than those in the great majority of commercial and manufacturing schemes. The product has an unalterable value and constant demand, not affected by trust, statute or panic, which is more than can be said for any other mineral or agricultural product in the world.

It seems rather strange that the United States has thus far produced little or no tin. Small deposits exist in vari-

ous parts of our wide domain, but the repeated attempts to work them have, without exception, resulted in failure. Large tin-ore bodies may yet be discovered, possibly in the great granitic areas of Idaho, which are as yet practically unknown, even in a geographical sense. Our present supply of tin comes altogether from the Malay Peninsula and the adjacent islands. How long these deposits can meet the world's great demand upon them there is no means of ascertaining. From all I can learn, much of the tin-bearing area of these regions has been exhausted. It is probable, however, that new deposits will be developed in Siam, Borneo and Sumatra.

The production of copper in the United States has increased from 295,812,076 pounds in 1891 to 606,117,166 pounds in 1900; that is, 310,305,090 pounds or about 51½ per cent.—a greater ratio of increase than that shown by any of the other metals. This condition has no doubt been caused by the enormous demand for this metal in the electrical arts, with a consequent high price, and also improvements in methods of extraction from its ores. The result has been that vast quantities of low-grade ores can now be operated at a profit, whereas a few years ago it was impossible for them to compete with the rich and unique deposits of Lake Superior. New deposits of lean-ores are being discovered througout the Western mining states and territories, notably in Arizona; but as yet no notably rich stores of this metal have been reported. It is therefore unlikely that the demand will be oversupplied and the present price naturally reduced unless some other metal or substance can be found to replace copper in electrical constructions, which is not at all likely. In fact, the returns for 1901 show a reduction, the total production being 595,000,000 pounds for the year, a falling off of about 18 per cent. The pneumatic or Bessemerizing process for the treatment of mattes and electrolytic refining has been of inestimable value to the industry, and there seems to be a constant and steady improvement in all other directions; hence, the outlook for the future of copper production is most encouraging.

The lead industry has not been marked by any great

advance during the past decade, although a steady, moderate increase has been manifested from year to year. Southeastern Missouri is still the center of the purely lead-mining business. Here we have peculiar deposits known as "disseminated" lead-ore, which show no signs of exhaustion, but, on the contrary, the developments from year to year tend to the conviction that these great sheets of galena cover a larger area than has heretofore been suspected. It is most probable, therefore, that Missouri is likely to maintain her prominence as a lead-producer for many years to come.

The production of zinc has, likewise, not been largely increased, notwithstanding the phenomenal activity in the Joplin Region in 1899 and 1900. The zinc-ores of this district are by far the best in the world, but the deposits are relatively small, pockety, uncertain, and of slight depth. The area covered by them, however, is great, and the district as a whole is as yet but slightly developed. These ores, however, must now compete with the cheaper ores from the silver-lead districts of the Rocky Mountains. This, together with the relatively slight increase in the consumption of zinc in the arts, has kept prices low. The Joplin miner has, therefore, been confronted with a falling market for his ore and a steady rise in the cost of supplies, fuel and labor; for which reasons his lot for the past year or two has not been an altogether happy one; and most of the many enterprises floated during the Joplin boom of 1899 have come to an unfortunate end.

In the metallurgy of zinc there have been no radical improvements. Gas-firing of the retorts is now adopted whenever it is found possible, and when natural gas is not available, producer-gas is used. Some advance has been made in the system of roasting, a process which has hitherto been crudely carried on.

The production of quicksilver in the United States shows a decided decline, notwithstanding the steadily increasing demand for it. The greater part of the production comes from California; but these mines are beginning to show symptoms of exhaustion. Cinnabar has recently been found in quantity in Texas and in British Columbia,

and within the past four months is reported from the Thunder Mountain district of Idaho.

As is the case with tin, it will soon be a serious matter to obtain a sufficient supply of quicksilver to meet the world's demand. The older deposits have about reached their limit of production, and no new supplies are reported save those in Kwei Chau province in China; but how soon these apparently great deposits will be available is very uncertain. From what little personal knowledge I have of the geology of Central Idaho and Eastern Oregon, I would not be surprised if cinnabar in workable quantities would eventually be discovered in these as yet little-known (in a geological sense) regions.

One of the remarkable and surprising incidents of the mineral development of this country during the past decade has been the discovery of the vast extent of the regions containing petroleum. These deposits appear to exist in rocks ranging all the way from the older Devonian of Pennsylvania to the comparatively recent Tertiary of Texas and California. The newly discovered Texas deposits appear to be of a richness equaled only by the famous deposits of the Caspian Sea Region. The oil of the younger rocks differs somewhat from that of Pennsylvania, which, all things considered, is probably the best in the world. Good flowing wells have recently been struck in Utah and Wyoming, and it is not at all improbable that the oil-yielding territory may be still further extended.

TECHNICAL NOTES FROM VARIOUS SOURCES.

——RUBBER IN VENEZUELA is the subject of a most interesting report in the Consular Bulletins of the State Department from Consul Goldschmidt, of La Guayra. It embodies a description of the caoutchouc of the Upper Orinoco by Dr. Lucien Morisse, who says that 50,000 emigrants could easily be employed in the forests gathering the gum, and cutting the trees, without any injury to the permanence of the supply.

——AN ARTESIAN WELL in Grenelle, France, took ten years of continuous work before water was struck, at a depth of 1,780 feet. At 1,259 feet over 200 feet of the boring rod broke and fell into the well, and it was fifteen

months before it was recovered. A flow of 900,000 gallons per day is obtained from it, the bore being 8 inches. At Passy, France, there is another artesian well 1,913 feet in depth, and 27½ inches diameter, which discharges an uninterrupted supply of 5,500,000 gallons per day; it cost $200,000. An artesian well at Butte-aux-Cailles, France, is 2,900 feet in depth, and 47 inches diameter. These are all surpassed by an artesian well in Australia, which is 5,000 feet in depth.

——*The Electrician* states that a proposal has been submitted to the municipal authorities at Rouen, by the chief of the fire department, for *the utilization of tramway trolley wires in connection with the extinguishing of fires.* All the principal thoroughfares of the town are provided with electric tramways, and the proposal is that pumps capable of being electrically driven should be installed in a number of suitable positions on the tramway route, to be switched on to the trolley wires, so that the pumps may be used as occasion necessitates. The proposal is said to have been favorably received, and is now under the consideration of the authorities.

——In a recent lecture in Philadelphia, Sir Robert Ball is reported to have utterly discredited any idea of "*talking with Mars.*" Sir Robert estimated that to signal Mars so as to be seen by a Martian astronomer who happened to be looking this way, using the wigwag system, we should need a flag 300 miles long and 200 miles wide, waved from a staff 500 miles long. Flash-light signaling he considers equally impracticable. If Lake Superior could be filled with petroleum and set on fire, the resulting blaze might be discerned as a speck of light, but not sufficiently prominent to suggest that anything unusual was in progress. He does not appear to have considered electrical means worthy of discussion.

——In order to combat *the smoke nuisance*, the Prussian government called together a committee for the trial of all smoke-consuming apparatus, says *The Engineer.* This committee has finished its work, and common measures are about to be taken to remove the evil. It was proposed to institute schools where stokers could be specially trained for the handling of steam-boiler plants. The Steam Boiler Revision Association consulted most of the branch associations, and the result was that most of them were against the idea of the schools; but it was proposed to send properly qualified men to instruct the stokers employed in the various steam plants.

——The Aurora, Elgin and Chicago Railway, now being built, will employ a third rail weighing 100 pounds per yard. This road is to give a high-speed service between Chicago, Aurora, and Elgin by way of Wheaton. The track is being laid with a view of maintaining a maximum speed of 70 miles an hour on the level, and the motor equipments which have been ordered are designed for that speed. The General Electric train control system is to be used on the cars, and there are to be four 125-horsepower motors on each car.

IN MEMORIAM.

JOSEPH RICHARDS.

Joseph Richards was born in Stourbridge, near Birmingham, England, in 1840, and in his youth was a machinist in Chance Brothers' chemical works, where his father was a departmental superintendent. He studied chemistry at the Midland Institute, Birmingham, where he attended Hofmann's lectures. One of his classmates was Joseph Chamberlain, now Great Britain's Colonial Secretary. Later he was in partnership with his father in the business of manufacturing chemists, making copperas, blue vitriol, and ammonia salts from gas-liquors. In 1871 he came to America, intending to take charge of a plant for working the gas-tar liquors of the Chicago gas-works, but the day before he was to start West, the great Chicago fire wiped out the whole plant. Finding himself in Philadelphia, he started to re-work the waste dross from galvanizing pots, and soon built up a large business, refining as much as 3,000 tons a year. His process was patented, and depended upon the treatment of the dross with sulphur vapor at a red-heat, whereby most of the iron was sulphurized, the remainder collecting at the bottom as an iron-zinc alloy. Later, the Delaware Metal Refinery was incorporated to work this process, and also to reduce waste oxides of lead and tin, and to manufacture solders.

JOSEPH RICHARDS.

A specific gravity balance, to test the grade of lead-tin solders, was devised by him, and is now in almost universal use in the solder trade. It is described in this *Journal* (May, 1899), and its value was recognized by the Franklin Institue by the award of the John Scott medal.

Later, the firm was one of the first to commence the manufacture of tin and terne plates, and Mr. Richards devised an ingenious balance for determining the amount of coating on specimens of such sheets. Since 1885 he was deeply interested in the production and possible uses of aluminum. He found many uses for the metal at a time when its cost ($8 per pound) made its application impracticable, but which have since come into general use. He patented the use of aluminum in deoxidizing and refining zinc and brass; also its use in small quantities in galvanizing pots. He devised and patented the most successful solder for aluminum which has yet appeared; a solder which has been in use ten years here and in Europe. This invention also was awarded the John Scott Medal on the recommendation of the Franklin Institute. He had large experience in remelting, handling and working aluminum; his hard, light alloys of aluminum with zinc being now in general use, and are acknowledged to be the cheapest light aluminum alloys of high quality to be had. Much of his experience in handling and treating white metals and their wastes is embodied in two communications to the *Journal of the Franklin Institute* (June and July, 1901). He was an active member of the Institute, having been succcessively President of its Metallurgical, Chemical, and Electrical Sections.

Besides being well known in the zinc, lead, tin and aluminum industries, he had a wide circle of most intimate and cherished friends, for to know him was to admire his equable and genuine character and to become attached to his attractive personality. From scientific acquaintances of the highest position to his humblest workman, he was beloved as a "best friend." He died in Philadelphia, March 22d, aged 62, leaving a widow and three children; his only son is Prof. Joseph W. Richards, of Lehigh University, the well-known writer on "Aluminium," and President of the American Electrochemical Society. His youngest daughter Florence H. Richards, is a practising physician in Philadelphia.

W. H. W.

STACY REEVES.

Stacy Reeves, a prominent master builder, and for a number of years a member of the Board of Managers of the Franklin Institute, departed this life March 8, 1902, in his seventy-fourth year.

Mr. Reeves was born on his father's farm, near Mt. Holly, Burlington County, N. J., on June 16, 1828. Here the early years of his childhood were spent. After the death of his parents—both of whom he lost during his childhood—he was placed in the home of a distant maternal relative, where he remained until fifteen years of age, attending the primitive country schools of the neighborhood during the winter and assisting about the farm in the summer months.

STACY REEVES.

After spending one year at the Friends' School at Westtown, he was apprenticed to Mark Balderston, a leading master carpenter of Philadelphia, with whom he learned his trade. He continued in the employ of Mr. Balderston some two years after reaching his majority. In 1851 he established himself in the business in which he continued with conspicuous success until the time of his death.

In 1862-63 he served in the Civil War as a member of the Pennsylvania Militia.

In 1869 he joined the Carpenters' Company, the oldest association of its kind in America (having been established in 1724). Of this association he served successively as Secretary (1889 to 1891); Vice-President (1892), and President (1895).

He was one of the charter members of the Master Builders' Exchange, of Philadelphia; was for a number of years one of its directors, and became its third President.

For a number of years prior to his death he was one of the directors of the Penn National Bank.

Mr. Reeves became a member of the Franklin Institute in 1889. He was chosen as manager in 1890 and served continuously until his death. For several years he also served as one of the curators, in which capacity his skill and experience as a builder proved extremely useful in connection with the extensive alterations to the library and reading room of the Institute, which were made about four years ago. In many other affairs of importance his colleagues in the board were wont to place the utmost dependence in his sound judgment.

The business that he founded in 1851 did not assume large proportions until after the Centennial Exhibition, in 1876, but in later years it grew very rapidly into prominence. The firm enjoyed the reputation of being one of the most conservative and reliable in the city. His son, Albert A., was taken into partnership in 1877, and a younger son, Henry, in 1885, and the firm name was changed to that of Stacy Reeves & Sons.

The firm founded by Mr. Reeves constructed many prominent buildings in Philadelphia and its vicinity. Among them are: The Wood Building, at Fourth and Chestnut Streets; Drexel Building, at Fifth and Chestnut Streets; Forrest Building, on the east side of Fourth Street, south of Chestnut; Hotel Lafayette, on the west side of Broad Street, south of Chestnut; the Lehigh Valley Railroad Buildings, at Mauch Chunk, Pa.; Lehigh University, at Bethlehem, and the Industrial School, built by the Misses Drexel, at Eddington, Bucks county. The restoration of the historic Independence Hall, ordered by the City Councils several years ago, was also undertaken and carried out by the firm.

Personally, Mr. Reeves was one of the most modest and unassuming of men. His sound business judgment was held in high esteem by his colleagues, and his advice and co-operation were never withheld when asked for. He will long be remembered for his sterling traits of character by his associates in the Institute, who sincerely deplore his loss.

W. H. W.

ANNUAL REPORTS OF THE DIRECTORS OF THE SCHOOLS OF DRAWING, MACHINE DESIGN, AND NAVAL ARCHITECTURE FOR THE SESSIONS 1901–1902.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 25, 1902.

THE DRAWING SCHOOL:—It gives me great pleasure to announce that the classes have been larger this season than for many years, and that the attendance has kept up to the end better than ever before. This is not only complimentary to the school, but also shows that the students are here for business, and that they come here because they know that the time will be profitably employed and the results will be practical and useful to them in their various careers.

The industrial interests of the country are becoming so immense and the requirements in the way of knowledge and technic so great, that it behooves the young men of the land to take advantage of every opportunity to learn everything bearing upon, or of use in, their various trades and professions.

They will find that mechanical drawing is the very best study to start with. It trains their imaginations to conceive the location and relation of points, lines and surfaces, the combination of these into simple solids, and so on up to complicated forms and their movements. It awakens a desire to understand the geometry of the forms and the kinematics of the movements, and thus leads up to the mathematics of the subject.

The work is interesting and gratifying, and no one who follows it up with ordinary application can fail to be greatly improved and to have his prospects and position bettered by it. That these facts are becoming better known and understood, the growth of the school and the work of the students amply testify.

My assistants this season have been: Mr. Clement Remington, Mr. John Rae, Mr. Edward V. Hindle, Mr. A. N. McConnell, and Mr. W. W. Twining.

Appended hereto are some data relating to the Branch School at Germantown Junction, which is in a flourishing condition.

WM. H. THORNE, *Director.*

THE BRANCH SCHOOL is located at No. 2906 N. Sixteenth Street, and it is readily accessible by the trains of the Pennsylvania and Reading Railroads and by the trolley cars. It is under the immediate direction of Mr. Haakon E. Norbom. The same text-books are employed and the same methods of instruction are followed as in the Central School. Pupils enjoy the same privileges also as to attendance upon the lectures. The Branch School is devoted exclusively to the teaching of Mechanical Drawing—the classes being divided similarly into Junior, Intermediate and Senior Classes. The beginning and ending of the winter and spring terms and the times of holding the classes and terms of instruction are the same as those of the Central School.

It is very gratifying to see the steady increase in the attendance at these night sessions. Last year it was found necessary to increase the desk room by building an annex which would accommodate two-thirds more than the original number of scholars. The year just ended (the eighth) shows an attendance for the two terms of 128, which tests the increased facilities of the school to the utmost.

Tickets for the Branch School can be obtained by addressing F. Macomb Cresson, at the office of George V. Cresson Company, Allegheny Avenue, west of Seventeenth Street.

THE FOLLOWING STUDENTS ARE ENTITLED TO HONORABLE MENTION:

In the Senior Mechanical Class.

Charles F. Miller,
Bernard G. Smith,
L. Hastings Alexander,
Herman Ruch, Jr.,
Elmer B. Severs,
Frederick Thomas Uezzell,
Elmer S. Hicken,
James Wilmer Shaffer,
Frederick Schoen,
Charles H. North.

In the Intermediate Mechanical Class.

George Blair,
Howard W. Howitz,
Christ. Bockius,
Herman Kilburger,
Henry O. Schmitt,
Otto A. Guenther,
Henry S. Cowell.

In the Junior Mechanical Class.

Richard H. Marshall,
Chester Dall,
Benjamin F. Norman,
Clarence Vent,
C. M. Markoe.

In the Architectural Class.

Harry Stull,
Eugene Fisher,
Joseph Hettel,
John Armour,
Powel Dilworth,
D. M. Donjian.

In the Free-Hand Class.

Edward Rush,
Alfred Thornton,
Benjamin Feldman.

THE FOLLOWING STUDENTS ARE AWARDED SCHOLARSHIPS FROM THE B. H. BARTOL FUND, ENTITLING THEM TO TICKETS FOR THE NEXT TERM:

Leonard Hoerle,
Clarence Helmbold Wilson,
James F. Bowen,
J. B. Minick,
J. Warren Smith.

THE FOLLOWING STUDENTS HAVING ATTENDED A FULL COURSE OF FOUR TERMS, WITH SATISFACTORY RESULTS, ARE AWARDED CERTIFICATES:

L. Hastings Alexander,
John Bardsley,
Daniel W. Dallin,
John F. Dyson,
Ernest Erhardt,
John Folz,
James E. Guenther,
Harry Fred. Hawkins,
Elmer S. Hicken,
John Franklin Horner,
Franklin S. Hodge,
John Leschinsky,
Charles F. Miller,
James E. Murphy,
William J. McFarland,
Herman Ruch, Jr.,
Edgar C. Sattler,
James Wilmer Shaffer,
George W. Simons,
Bernard G. Smith,
Merritt Sticker,
August Suess,
Eugene Fisher.

AND FROM THE BRANCH SCHOOL:

John Francis Kiely,	Ario Pardee Housman,
Charles F. Sturm,	Ernest R. Strenger,
Edward E. Fenstermaker,	David B. Mealing,

George W. Vache.

SCHOOL OF MACHINE DESIGN:—While our expectation of a large increase in attendance has not been fully realized, the increase has been substantial, and in this respect the school is experiencing a healthy growth.

The earnestness and enthusiasm of the students in prosecuting their task is very gratifying. The excellent grade of work done is attested by the drawings presented herewith, which form a small portion of the problems assigned.

Instruction has been carried on by a judicious mingling of lectures and individual instruction following some standard text-book as a basis and by supplying hectograph copies of notes on the more difficult parts of the subjects.

Great care has been taken in presenting the details of the various subjects, and no theorems within the range of the students' mathematical knowledge have been allowed to pass unproved. This is particularly true of the course on the strength of materials, in the text-book of which much is taken for granted. Though the task of supplying proofs adapted to the conditions has involved considerable labor, the results attained have justified the expenditure of energy.

For the very satisfactory manner in which the mathematical work has been conducted I am indebted to my friend and colleague, Mr. E. H. Waldo.

LUCIEN E. PICOLET,
Director.

THE FOLLOWING STUDENTS HAVING COMPLETED THE COURSE ARE AWARDED CERTIFICATES:

James Anderson,	H. C. Gibson,
H. N. Becker,	Nathan L. Jones,
G. H. Benzon,	Harry J. Stephan,
Edw. J. Beuter,	Wm. Williams.

THE SCHOOL OF NAVAL ARCHITECTURE:—I have the honor to report that the school of Naval Architecture has more than doubled its enrollment of last year, and that the average attendance for the senior division during the winter term was 90 per cent., and for the spring term 90·9 per cent., and for the junior division 90·3 per cent. for the winter term and 90·5 per cent. for the spring term. Nine of the senior class have attended the full term of two years and will be graduated this term.

The senior class has studied and examined all kinds of general arrangements and the details of fittings for same, and completed the necessary calculations that are required for the proper and efficient design of any vessel. They have made themselves proficient in the use of the integrator, estimating costs, calculating weights of material and centers of gravity, strength of structure of the hull under different conditions, as well as the powering of ships. Their home-work has shown wonderful energy, considering that the drawings, etc., are made without the help of the usual adjuncts of a drawing

office. In fact, the graduating class has exhibited more than ordinary intelligence, and its members are neat and careful draughtsmen, zealous and painstaking.

The junior students have progressed rapidly in both theoretical and practical naval architecture, and have also shown marked zeal in their work both in class and at home, numerous drawings and tracings beyond the average in neatness and accuracy having been made from blue-prints and drawings lent for that purpose.

By the kind permission of Mr. Morse, the president of the New York Shipbuilding Company, Camden, N. J., the class was allowed to inspect that company's plant as well as to witness the successful launch of a large cargo steamer. The class is also indebted to the following gentlemen for donating very valuable prizes for attendance, homework and examinations:

Mr. C. H. Cramp, president of the Wm. Cramp & Sons, ship builders and engineers, Philadelphia, Pa.; Mr. H. W. Morse, President of the New York Shipbuilding Company, Camden, N. J.; Mr. Lewis Nixon, proprietor and manager of the Crescent Shipyard, Elizabethport, N. J.; Mr. Clement A. Griscom, president of the International Navigation Company, Philadelphia, Pa. Mr. C. H. Cramp has also offered a special prize to the apprentices employed by his firm who are students of this school, and who show marked zeal and efficiency.

ALEX. J. MACLEAN,
Director.

THE FOLLOWING STUDENTS ARE AWARDED CERTIFICATES:

Wm. Binder,
M. M. Borden,
N. H. Brown,
F. M. Evans,
O. B. Evans,
C. H. Harden,
H. B. Shields,
J. L. Warner,
H. Yeager.

BOOK NOTICES.

Lessons in Applied Electricity, principles, experiments, and arithmetical problems. An elementary text-book. By C. Walton Swoope, Assoc. Am. I. E. E., etc. 8vo, pp. XIII + 462. New York: D. Van Nostrand & Co., 1901. (Price, $2.00.)

This work was originally prepared for use by the pupils of the evening classes in practical electricity, at the Spring Garden Institute, in Philadelphia, which were in charge of the author.

The various lessons embrace the following subjects: magnetism, magnetization, magnetic fields, theory of magnetism, magnetic induction, magnetic circuits, earth's magnetism, voltaic electricity, batteries, electrolysis, measurement of current strength, resistance, Ohm's law and battery connections, measurement of resistance, electrical development of heat, electro-dynamics, electro-magnetic induction, the induction coil, dynamo-electric machines, armatures, direct-current dynamos and motors, electric lighting.

To each chapter is appended a series of questions to test the progress of the pupil. The book is profusely illustrated. W.

The Engineering Index: Five years, 1896–1900. Edited by Henry Harrison Suplee, B.Sc., etc., assisted by J. H. Cuntz, C.E., M.E. 4to, pp. 1230. New York and London: *The Engineering Magazine*, 1901.

A feature of the *Engineering Magazine* that has contributed greatly to its usefulness, is the index of current engineering literature published with each impression. The present volume has been re-edited from the *Magazine* and embraces "The Engineering Index" of that journal, from 1896 to 1900, inclusive. It constitutes the third of these volumes, the previous issues covering respectively the years 1884–1891 and 1892–1895. The arrangement is by subject-matter, with elaborate cross-references. W.

A Laboratory Guide to the Study of Qualitative Analysis. By E. H. S. Bailey, Ph.D., Professor of Chemistry, and Hamilton P. Cady, A.B., Assistant Professor of Chemistry, in the University of Kansas. Fourth edition. 12mo, pp. 235. Published by P. Blakiston's Son & Co., 1991. (Price, in cloth, $1.25, net.)

The authors explain in their preface that they have sought in this work to teach not only the facts and the mechanical methods of carrying out the various operations of analysis, but also to render them more intelligible and interesting to the student by a proper application of the theory of Electrolytic Dissociation and of the Phase Law. A new method is presented for the separation of arsenic, antimony, and tin, and also for the separation and identification of the acids. W.

Franklin Institute.

[*Proceedings of the Stated Meeting held Wednesday, April 16, 1902.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 16, 1902.

President JOHN BIRKINBINE in the chair.

Present, 70 members and 18 visitors.

Additions to membership since last report, 7.

The order of business was suspended in order to permit of final action on the amendments to the By-laws presented at the stated meeting of March 19th.

After a prolonged discussion of the several proposed amendments, which occupied the major portion of the meeting, they were severally adopted by more than the required two-thirds vote of the members present.

In substance, the amendments as adopted increase the annual dues of contributing members from $8 to $15, and for fractional parts of the year proportionately; the dues of non-resident members from $2 to $5; the dues of resident life members from $100 to $200, and of non-resident life members from $40 to $75; and the annual tax on second-class stock from $6 to $12, and for fractional parts of a year proportionately.

The number of members of the Committee on Science and the Arts was increased from forty-five to sixty, of whom it is provided that twenty shall be retired each year.

The following members were elected to the committee in conformity with the amendment just referred to, viz.:

Robt. D. Kinney, Frank Roselle, D. A. Partridge, Caspar Wistar Haines, Ernest M. White, Sam'l P. Sadtler, W. N. Jennings, Henry Leffmann, Jesse Pawling, Jr., E. Goldsmith, Robt. H. Bradbury, Werner Kaufman, Clayton W. Pike, Chas. Murset, Rich'd L. Humphrey. Also, Mr. John Price Wetherill was elected to the Board of Managers to fill the vacancy caused by the death of Mr. Stacy Reeves.

Adjourned.

WM. H. WAHL, *Secretary.*

COMMITTEE ON SCIENCE AND THE ARTS.

[*Abstract of proceedings of the stated meeting held Wednesday, April 2d—Adjourned meeting Friday, April 11th, 1902.*]

The following reports were adopted:

(No. 2132.) *American Roller Bearing Company's Roller Bearing.*—Myron F. Hill, Cambridge, Mass.

This subject is one of those recommended for investigation by the Jury of Awards of the National Export Exposition.

ABSTRACT.—The invention is the subject of letters-patent to Mr. Hill granted in several foreign countries.

The sub-committee made tests of the bearing as applied to vehicles, and finds as follows:

"The most noteworthy feature of these bearings is their excellent workmanship, the closeness of the gauging and the hardening of the rollers and racers. Although the principles used in this bearing are not new, the excellent workmanship and the production of a successful bearing are worthy of recognition. A Certificate of Merit is accordingly granted to Myron F. Hill, the inventor." [*Sub-Committee.*—Arthur M. Greene, Jr., Chairman.]

(No. 2181.) *Enclosed Arc Light.*—C. J. Toerring, Philadelphia.

ABSTRACT.—The lamp is of the enclosed arc type, and is intended to burn on direct-current, constant potential circuits of 110 and 220 volts.

The inventor does not disclose anything fundamentally new, but evidences careful attention to details.

Thus, the inventor uses a large inner globe, which embraces the lower carbon holder, and which, being farther away from the arc, is less liable to be broken; also, it allows the introduction of the hand in cleaning. The design and material of the steadying resistance is a feature. This is so arranged that in case the carbons become stuck together, it will carry the current without injury.

The lamp was tested by the sub-committee, and the claim of the manufacturers of a life of over two hundred hours, with ordinary half by twelve-inch "Electra" carbons, was verified, as well as the lasting power of the resistance for over twenty-four hours. The award of a Certificate of Merit is made to the inventor. [*Sub-Committee.*—Francis Head, Chairman; Richard L. Binder.]

(No. 2183.) *Stencil Machine.*—Andrew J. Bradley, St. Louis, Mo.

ABSTRACT.—This subject relates to a machine for cutting paper stencils used in marking addresses, shipping directions, etc., on cases, boxes, etc., and is the subject of several letters-patent to applicant. The details of the machine cannot be made intelligible without the aid of illustrations, and reference must therefore be made to the specifications filed with the report.

The committee finds that the Bradley machine is the only one on the market for doing this special class of work, and that it answers its purpose very satisfactorily, the brand being clear and easily read, avoiding the mistakes in shipments which frequently occur when hand-marking is used because of its illegibility and the difficulty usually met with by any one but an expert in forming letters legibly with a brush.

The cutting of the stencil with this machine is as quickly done as the writing of an address on an envelope with the typewriter, and the marking is done by the slight passing of a brush over the stencil on the surface to be marked. As many as 1,000 impressions have been made from the same stencil without noticeable wear or defacement. The question of time lost in hunting up old stencils is answered by the fact that it is quicker to make a new one.

The award of the John Scott Legacy Premium and Medal is recommended. [*Sub-Committee.*—J. Logan Fitts, Chairman; Samuel Sartain, Henry F. Colvin.]

(No. 2195.) *Single-phase Motor.*—Wagner Electric Company, St. Louis, Mo.

The invention is covered by letters-patent No. 389,352, September 11, 1888, to Messrs. Anthony, Jackson & Ryan, and relates to the general scheme of using a closed external circuit in connection with the armature, using a commutator on the same, current only being supplied to the field.

Another patent granted to Arnold, No. 543,836, August 6, 1895, introduces the idea of using the closed circuit on the commutator brushes and also a governor on the shaft, operating a short-circuiting ring on the commutator.

Other and more recent patents—Pillsbury & Schwedtmann, No. 620,609, March 20, 1899, and No. 603,709, May 10, 1898—to Schwedtmann relate respectively to the special form of governor, brush-holder and commutator arrangement and the arrangement of the field winding; the use of a special form of frame and the method of holding the stator in the frame.

The sub-committee's conclusions are as follows: The Wagner Electric Company has developed a practical single-phase motor which has given satisfactory service in commercial use.

In view of the fact that this is a distinct departure from other types of self-starting single-phase motors, which either start as series motors or make use of phase-splitting device to obtain their starting torque, the Edward Longstreth Medal of Merit is granted to the manufacturers. [*Sub-Committee.*—Arthur J. Rowland, Chairman; Thomas Spencer, Carl Hering, L. F. Rondinella.]

(No. 2185.) *Process of Treating Tool Steel.*—Fred. W. Taylor and Maunsel White, Bethlehem, Pa.

This report is reserved for publication in full. The committee's conclusion is as follows: In conclusion, the sub-committee takes pleasure in recom-

mending the award of the Elliott Cresson Medal to the inventors, for their discovery and development of a method of treating a certain composition of tool steel, which has made it possible to largely increase the output of machines doing roughing work. [*Sub-Committee.*—Charles Day, Chairman; James Christie, Wilfred Lewis, A. Falkenau.]

(No. 2205.) *Automatic Electric Brake Motor.*—Gano S. Dunn, East Orange, N. J.

ABSTRACT.—The invention is the subject of U. S. letters-patent, No. 515,755, March 6, 1894, and No. 654,142, July 24, 1900, to applicant.

The motor is specially designed for use on bi-polar machines. The brake mechanism is of the band type, and is so arranged as to be operated in one or both directions. The motion of applying the brake-band is imparted by means of a spiral spring, which is allowed to go into action as soon as the current is thrown off the field magnet.

When the machine is at rest and the field not energized, a heavy coil spring pushes this movable pole piece away from the armature, and tightens a leather-lined band which grips a brake-wheel attached to the spider of the armature. When the current is thrown on, the magnetism of the field draws the movable pole piece inward, overcoming the force of the coil spring, and causing the brake-band to release the brake-wheel, thus leaving the armature free to rotate. Thus, it will appear that the brake is automatic in action; that the field resumes its normal position when the motor is in operation, and that no extraneous coil or other mechanism is required, the brake spring being overcome and the armature released by the static attraction of the field. The spring and brake-band are adjustable, so that the armature may be allowed a few revolutions in which to slow down before stopping, or be stopped and held firmly the instant the current is shut off; and in all cases the friction of the brake is greater than the driving power of the motor, so that a brake motor is able to hold up any load which it is able to hoist.

The report proceeds then to describe machines of the reversible type embodying the same general principles of construction, and gives the results of the committee's examination of a number of motors equipped with this brake, which were at the Pencoyd Iron Works.

The report concludes that the device is ingenious, that the details have been carefully worked out, and that this motor fills satisfactorily a certain field of operation. A Certificate of Merit is awarded to the inventor. [*Sub-Committee.*—Messrs. C. L. Eglin, Chairman; Clayton W. Pike, Arthur J. Rowland, C. J. Reed.]

(No. 2209.) *Synchronism Indicator.* Paul M. Lincoln, Niagara Falls, N. Y.

ABSTRACT.—Letters-patent covering this device are granted to applicant, No. 685,155, October 22, 1901. The investigating committee had the opportunity of examining its operation at the power-house of the Philadelphia Electric Company.

The purpose for which this instrument is used is to synchronize two or more alternating current generators which it is desired to connect in parallel. It indicates the phase and frequency-relation of two separate sources of electro-motive forces. It also indicates which of the generators is operating at the higher frequency and what the difference is.

[For a full description of the instrument, with illustrations, the reader

is referred to the paper of Mr. Lincoln, read before the Electrical Section of the Institute, and published in the impression of the JOURNAL for April, 1902.]

The report continues that the only instruments available for the purpose prior to the invention of this device were either lamps or a voltmeter. Lamps were so arranged as to either be extinguished or be up to full candle-power when the two machines were in synchronism. The possibility of error is very great with the use of incandescent lamps, as there is a wide range of voltage from the point of unity until the filament commences to glow, which gives no indication to the operator of the difference of voltage or of the phase-relation of the two machines about to be connected. With the use of the voltmeter this difficulty is overcome, although it does not indicate which of the machines is running faster.

The committee finds that the instrument fully meets all the requirements of actual practice and greatly facilitates the connecting of alternating current machines in parallel. Also, that the instrument has been carefully designed and arranged in a practical form, and that it is a meritorious and ingenious invention. The report recommends the award of the John Scott Legacy Premium and Medal to the inventor. [*Sub-Committee.*—Messrs. C. L. Eglin, Chairman; Coleman Sellers, Thomas Spencer.]

(No. 2213.) *Nutrium.* A New Food Preparation. National Nutrient Co.

The product referred to is a dry, white powder, consisting of the solids of separated skimmed milk, obtained, according to the statements furnished to the committee, by evaporating the watery portion at a low temperature.

The committee awards a Certificate of Merit in the following terms:

"For the preparation of separated skimmed milk in a dry and finely pulverulent state so as to obtain all the solid ingredients in a permanent form without the use of preservatives." [*Sub-Committee.*—Henry Leffmann, Chairman; Bayard H. Morrison, Sarah Tyson Rorer, Frederick A. Genth, Jr.]

(No. 2215.) *Developing Tray for Photographic Negatives.* A. B. Sheppard, Burgettstown, Pa.

(An advisory report.)

(No. 2200.) *Method of Telephoning Over Electric Light and Power Circuits.* Frederick Bedell, Ithaca, N. Y.

(An advisory report.)

WM. H. WAHL,
Secretary.

SECTIONS.

(*Abstracts of Proceedings.*)

PHYSICAL SECTION.—Proceedings of the meeting, Wednesday, March 26. Dr. Mackenzie in the chair.

The paper of the evening was read by Dr. Albert P. Wills, on "Recent Work in Magneto-Striction." The paper was illustrated by lantern slides. Discussed by Dr. Lloyd, Dr. Goldsmith, Dr. Mackenzie and Mr. Pawling.

This was followed by a paper on "The Hearings of the Committee on Coinage, Weights and Measures on the Metric System," by Jesse Pawling,

Jr. The following motion, offered by Mr. Pawling and duly seconded, was adopted:

To appoint a committee of the Physical Section to formally call the attention of other scientific, technical and manufacturing bodies to the action of the Franklin Institute, and to request that the subject be taken up for consideration, and to obtain opinions from individuals prominently identified with educational, scientific, engineering, technical, manufacturing and commercial work, as to the desirability of such legislation; and to report to the Physical Section of the Franklin Institute at its next meeting what other steps might be taken with propriety to further the proposed metrological reform. Discussed by Dr. Lloyd, Dr. Goldsmith and Dr. Mackenzie.

The President appointed on the above-named committee Jesse Pawling, Jr., Chairman; Dr. Geo. F. Stradling and Dr. A. E. Kennelly.

The thanks of the Section were tendered to Dr. Wills for his paper.

Adjourned.

JESSE PAWLING, JR., *Secretary.*

SECTION OF PHOTOGRAPHY AND MICROSCOPY.—*Stated Meeting*, held Thursday Evening, April 3, 1902. President, Dr. Henry Leffmann in the chair. Present, 17 members and visitors.

Mr. Lewis Woolman read the paper of the evening, entitled "Microscopic Organisms in the Determination of Geologic Age." Mr. Woolman exhibited a large number of lantern slides, illustrating the subject, and also a number of mounted specimens which were projected on the screen with the lantern microscope. These were also shown under the table microscope. The speaker also presented a number of photographic illustrations of some features of the subject.

Mr. F. E. Ives exhibited a number of photo-micrographs that he had made of diatomes and other test objects.

The chairman presented to Mr. Woolman the thanks of the meeting for his interesting communication. Adjourned.

MARTIN I. WILBERT,
Secretary.

MINING AND METALLURGICAL SECTION, ELECTRICAL SECTION.—*Joint Meeting*, held Thursday Evening, April 10th. Mr. A. M. Greene, Jr., in the chair. Present, 104 members and visitors.

Mr. F. W. Taylor, late of Bethlehem Iron Works, presented a paper on "Shop Management," in which were outlined the piece-work, premium and bonus systems of paying for labor, and the methods necessary to obtain "fair pay for a fair day's work," with satisfaction to the workingman and a just profit to the employer. The speaker emphasized the fact that, with proper management, high wages to first-class men means increased production and decreased cost.

The speaker gave some pointed illustrations of these facts by figures obtained from current practice at the Bethlehem Iron Works.

The paper was discussed by Messrs. Cyrus Chambers, Jr., Arthur Falkenau, Wilfred Lewis, Spencer Fullerton, A. M. Greene, Jr., and others. Adjourned.

D. EPPELSHEIMER, JR.,
Secretary.